Seaforth

WORLD NAVAL REVIEW

2020

Edited by
Conrad
Waters

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Editor
CONRAD WATERS

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Frontispiece: A busy picture at Daewoo Shipbuilding & Marine Engineering's Okpo shipyard in the Republic of Korea as the second Royal Fleet Auxiliary 'Tide' class fleet tanker, *Tiderace*, is towed out of dry dock on 28 November 2015 to allow final fitting out to commence. The tanker was accepted from her builders on 29 June 2017, entering operational service on 2 August 2018 after subsequent 'customisation' in the UK. *(Courtesy Shaun Jones)*

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Note on Tables: Tables are provided to give a broad indication of fleet sizes and other key information but should be regarded only as a general guide. For example, many published sources differ significantly on the principal particulars of ships, whilst even governmental information can be subject to contradiction. In general terms, the data contained in these tables is based on official information updated as of June 2019, supplemented by reference to a wide range of secondary and corporate sources, such as shipbuilder websites.

1 OVERVIEW

INTRODUCTION

Author:
Conrad Waters

'When bad men combine, the good must associate else they will fall one by one, an unpitied sacrifice in a contemptible struggle' wrote the Anglo-Irish statesman and philosopher Edmund Burke. His words were published in 1770 in the pamphlet *Thoughts on the Cause of the Present Discontents*, written in response to King George III's political meddling in the British legislature. Burke's statement has resonance some 250 years later in an era where emerging revisionist powers – particularly China and Russia – are seen by many as seeking to overthrow the 'rules based' world order established by the United States and its allies in the aftermath of the Second World War.

It is clear that the growing threat to American hegemony posed by expanding Chinese and Russian military capabilities – sometimes referred to as the 'axis of the authoritarians' – is exercising a dominant influence on US defence thinking. This focus was evident both in the US National Security Strategy (NSS) published in December 2017 and the National Defense Strategy (NDS) announced the following month. It has been a recurring theme in subsequent official publications. One example is the latest Worldwide Threat Assessment presented by America's Director of National Intelligence, Daniel R. Coats, on behalf of the US Intelligence Community in January 2019.[1] Observing that 'China and Russia are more aligned than at any point since the mid-1950s, and the relationship is likely to strengthen in the coming year …' he noted the expanding and diversifying threats to US national security and the increasing strain imposed on the post-Second World War international system.

The response is evident in the US Department of Defense's (DOD's) FY 2020 Budget Request. Emphasising the 'fundamentally different challenge' faced by the United States, it aims at 'ensuring our competitive advantage to compete, deter and win in an era of great power competition'.[2] The request envisages overall DOD spending rising around 5 percent to US$718bn but, even at this level, some hard choices will be required to adapt to the new environment. From a naval perspective, the result is a prioritisation of innovative, next-generation systems such as autonomous vehicles and next generation weapons technologies over more traditional platforms to prepare for a high-end future conflict. Perhaps the most notable symbol of changing priorities was a proposal – albeit quickly rescinded – to retire the aircraft carrier *Harry S. Truman* (CVN-75) halfway through her operational life to save the cost of an expensive refuelling of its nuclear reactor.

The latest budget explicitly references the need to strengthen alliances and attract new partners. However, it is this aspect of US policy that remains most problematic. This is partly a reflection of the negative international response to the Trump administration's 'America First' approach to global trade and its more transactional take on the benefits of long-established alliances, such as NATO. Whilst

Table 1.1: COUNTRIES WITH HIGH NATIONAL DEFENCE EXPENDITURES 2009-18

RANK 2018	(2009)	COUNTRY	TOTAL US$ BN 2018[1]	SHARE OF GDP 2018	WORLD SHARE 2018	TOTAL US$ BN 2009[1]	SHARE OF GDP 2009	REAL CHANGE 2009–2018[2]
1	(1)	United States	649	3.2%	36%	669	4.6%	-17%
2	(2)	China	[250]	[1.9%]	[14%]	[105.6]	[2.1%]	83%
3	(3)	Saudi Arabia	[67.6]	[8.8%]	[3.7%]	41.3	9.6%	28%
4	(5)	India	66.5	2.4%	3.7%	38.7	2.9%	29%
5	(6)	France	63.8	2.3%	3.5%	66.9	2.5%	2%
6	(4)	Russia	61.4	3.9%	3.4%	51.5	3.9%	27%
7	(7)	United Kingdom	50.0	1.8%	2.7%	57.9	2.4%	-17%
8	(9)	Germany	49.5	1.2%	2.7%	47.5	1.4%	9%
9	(8)	Japan	46.6	0.9%	2.6%	51.5	1.0%	2%
10	(10)	South Korea	43.1	2.6%	2.4%	24.6	2.7%	28%
-	**(-)**	**World Total**	**1822**	**2.1%**	**100%**	**1531**	**2.6%**	**5.4%**

Information from the Stockholm International Peace Research Institute (SIPRI) – https://www.sipri.org/databases/milex
The SIPRI Military Expenditure Database contains data on countries over the period 1949–2018.

Notes

1 US$ totals for 2018 and 2009 are based on then current (i.e. non-inflation adjusted) prices and exchange rates for the years in question. Exchange rate movements, in particular, can therefore result in significant movements in the US$ figures and explain apparent discrepancies in the table.

2 The 'real' change figure is based on constant (2017 based) US$ figures.

3 Figures in brackets are SIPRI estimates.

many might have sympathy with the administration's frustrations with its partners, the result – in the words of Director Coats – is that '… some US allies and partners are seeking greater independence from Washington in response to their perceptions of changing US policies on security and trade and are becoming more open to new bilateral and multilateral partnerships'. The abrupt resignation of respected US Defense Secretary James Mattis in December 2018 – driven partly by his perceptions of a lack of respect being shown to the unique and comprehensive system of alliances and partnerships on which US security depends – will not have helped reverse this trend.

The cohesion of the United States' relations with its European allies is likely to be further impacted by the United Kingdom's protracted withdrawal from the European Union, the process popularly known as 'Brexit'. Conclusion of Brexit will significantly reduce the UK's ability to act as an arbiter between the United States and Continental Europe, particularly with respect to the interface between NATO and the European Union's expanding security aspirations. One aspect of this political shift is a strengthening Franco-German alliance, most clearly evidenced by their signature of the Aachen Treaty on 22 January 2019. Although a bilateral document, the Aachen agreement placed great emphasis on developing joint military capabilities to bolster Europe's ability to act autonomously. Subsequently, influential German Christian Democratic Union party leader Annegret Kramp-Karrenbauer proposed a 'symbolic project' to build a common European aircraft carrier. Whilst it is questionable whether the development of this duplicate security architecture will enhance the protection enjoyed by Europe under the NATO alliance, it is an understandable reaction to persistent doubts about President Trump's longer term commitment to the North Atlantic Treaty.[3]

Meanwhile, a more immediate threat to NATO cohesion is provided by the growing spat over Turkish President Recep Erdogan's support for the acquisition of S-400 surface-to-air missiles from Russia. The United States fears that the secrets of its own technology may be compromised by the resultant Russian access to Turkey's military data. On 6 June 2019 Acting US Secretary of Defense Patrick Shanahan wrote to his Turkish counterpart announcing the ejection of Turkey from the F-35 Lightning II programme by 31 July if the S-400 purchase went ahead. If confirmed, the decision will force the abandonment of the Turkish Navy's plans to acquire F-35Bs to operate from the new amphibious assault ship *Anadolu*, which is currently under construction in Istanbul.

The US Navy aircraft carrier *Harry S. Truman* (CVN-75) cuts through the grey waters of the Atlantic Ocean in a December 2018 photograph. The carrier's early retirement was briefly considered in the US Navy's FY2020 budget proposals as the service attempts to find the resources to strengthen its competitive advantage against increasing Chinese and Russian military power. *(US Navy)*

DEFENCE BUDGETS AND PLANS

In spite of the return of great power competition, analysis conducted by the independent and widely-respected Stockholm International Peace Research Institute (SIPRI) suggests that global military expenditure in 2018 of some US$1,822bn increased by only a relatively modest 2.6 percent during the year. Moreover its share of GDP or global economic output – the so-called world military burden – actually reduced slightly to 2.1 percent, equivalent to the previous low seen in 2014. Details of the world's ten highest spending nations are provided in Table 1.1; eight of these ten countries (the exceptions being Saudi Arabia and Germany) can be considered major naval powers.

The table demonstrates the significant growth in China's defence spending over the last decade at a time when the two main Anglo-Saxon nations – the United States and the United Kingdom – have been cutting back defence budgets during a period of fiscal retrenchment. The rebound in Russian military spending is also noteworthy, as is the expansion achieved by Asian powers such as India and South Korea. However, as mentioned in many previous editions of *Seaforth World Naval Review*, the growing significance of the big Asian countries as military powers is more a factor of their relative economic success than an increased preference for 'guns over butter'. Indeed, all the Asian countries listed in the table are spending a slightly lower share of their economic output on defence than they did a decade ago.

Given that the United States' military budget remains by far the world's largest – still accounting for more than a third of overall global defence spending before the full impact of the Trump administration's increases take effect – the inevitable question is whether fears of the challenge from the revisionist powers are overblown. Part of the answer

was provided by an article on Russian defence spending posted to the *Defense News* website by Michael Kofman on 5 May 2019.[4] Noting that Russia pays for its hardware in roubles rather than dollars, Kofman focused on the distortions inherent in US$-based spending comparisons when assessing countries with self-sufficient defence manufacturing capabilities. On this basis, he suggested that real Russian defence purchasing power may be in the order of three times the SIPRI estimate at c. US$150–US$180bn.

More broadly, the Asia-Pacific area's continued economic outperformance is set to maintain the shift in the balance of power towards China and other Asian countries over time. As noted in the opening to *Jane's Defence Weekly*'s 2018 Annual Defence Report, '… while the United States has historically always swung from isolationism to playing the global policeman, under the new world paradigm Washington's ability to play the latter may be on the wane, even if it were inclined to do so.'[5]

FLEET REVIEWS

Meanwhile, the current global balance of naval power is set out in Table 1.2. Just as for the data contained in Table 1.1 on defence spending, these numbers have to be regarded with a degree of caution. For example, whilst the figures suggest little change in China's naval strength year-on-year, these mask the progressive replacement of obsolescent tonnage with powerful new warships, including many aimed at furthering China's 'blue water' aspirations. The last year has been notable for delivery of *Nanchang*, first of the c. 12,000-ton Type 055 destroyers. Commissioning of China's first fully indigenous aircraft carrier, an as yet unnamed Type 001A vessel based on the *Kuznetsov/Liaoning* design, is also believed to be imminent.

The apparently stable Russian data also warrants further explanation. Obtaining a true understanding of the real status of the Russian fleet is fraught with difficulty, with many 'legacy' Soviet era ships likely to be of questionable utility. Equally significant is the slow but accelerating replacement of these Cold War relics, principally with new submarines and littoral surface warships that are particularly well-suited to Russian anti-access/area denial (A2/AD) priorities. Recent arrivals have included *Mytishchi*, the first of a class of c. 800-ton Project 22800 'Karakurt' missile armed corvettes and the long delayed *Admiral Gorshkov*, lead ship of the much larger Project 22350 frigates. As has been demonstrated in the course of the Syrian Civil War, many of the new vessels are equipped with long-range cruise missiles that can strike at considerable distance from the Russian homeland.

This year's fleet reviews examine the strategies being pursued by three very different European fleets in the face of a resurgence of Russian naval power. Guy Toremans' review of the Finnish Navy examines both the significant process of modernisation that is underway under the 'Squadron 2020' acquisition programme and increasing – albeit cautious – collaboration with both EU and NATO

TABLE 1.2: MAJOR FLEET STRENGTHS 2018–2019[1]

REGION	THE AMERICAS				EUROPE & RUSSIA										ASIA								IND. OCEAN	
COUNTRY	USA		BRAZIL		UK		FRANCE		ITALY		SPAIN		RUSSIA		CHINA		JAPAN		KOREA(S)		AUSTRALIA		INDIA	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Carriers & Amphibious																								
CV/CVN	11	11	–	–	1	1	1	1	1	1	–	–	1	1	1	2	–	–	–	–	–	–	1	1
CVS/CVH	–	–	–	–	–	–	–	–	1	1	–	–	–	–	–	–	4	4	–	–	–	–	–	–
LHA/LHD/LPH	9	9	1	1	–	–	3	3	–	–	1	1	–	–	–	–	–	–	1	1	2	2	–	–
LPD/LSD	23	23	1	1	5	5	–	–	3	3	2	2	–	–	4	6	3	3	–	–	1	1	1	1
Submarines																								
SSBN	14	14	–	–	4	4	4	4	–	–	–	–	11	11	6	6	–	–	–	–	–	–	1	1
SSN/SSGN	54	55	–	–	6	7	6	6	–	–	–	–	25	25	9	9	–	–	–	–	–	–	1	1
SSK	–	–	5	5	–	–	–	–	8	8	3	3	20	20	50	50	18	19	16	17	6	6	14	14
Surface Combatants																								
BB/BC	–	–	–	–	–	–	–	–	–	–	–	–	2	2	–	–	–	–	–	–	–	–	–	–
CG/DDG/FFG	90	91	8	7	19	19	17	16	18	16	11	11	30	30	70	70	37	38	25	25	11	11	24	23
DD/FGS/FS	13	18	3	2	–	–	15	13	2	1	–	–	40	40	45	50	6	6	14	13	–	–	11	11
FAC[2]	–	–	–	–	–	–	–	–	–	–	–	–	35	35	75	75	6	6	18	18	–	–	8	8
Other (Selected)																								
MCMV	11	11	4	4	13	13	14	14	10	10	6	6	40	40	25	25	23	22	9	9	6	4	1	–
AO/AOR/AFS	29	29	1	1	8	9	3	3	3	3	2	2	20	20	12	12	5	5	3	3	2	2	4	4

Notes

1 Numbers are based on official sources, where available, supplemented by news reports, published intelligence data and other 'open sources' as appropriate. Given significant variations in available data, numbers should be regarded as indicative, particularly with respect to Russia, China and minor warship categories. There is also a degree of subjectivity with respect to warship classifications given varying national classifications and this can also lead to inconsistency.

2 FAC numbers relate to ships fitted with or for surface-to-surface missiles.

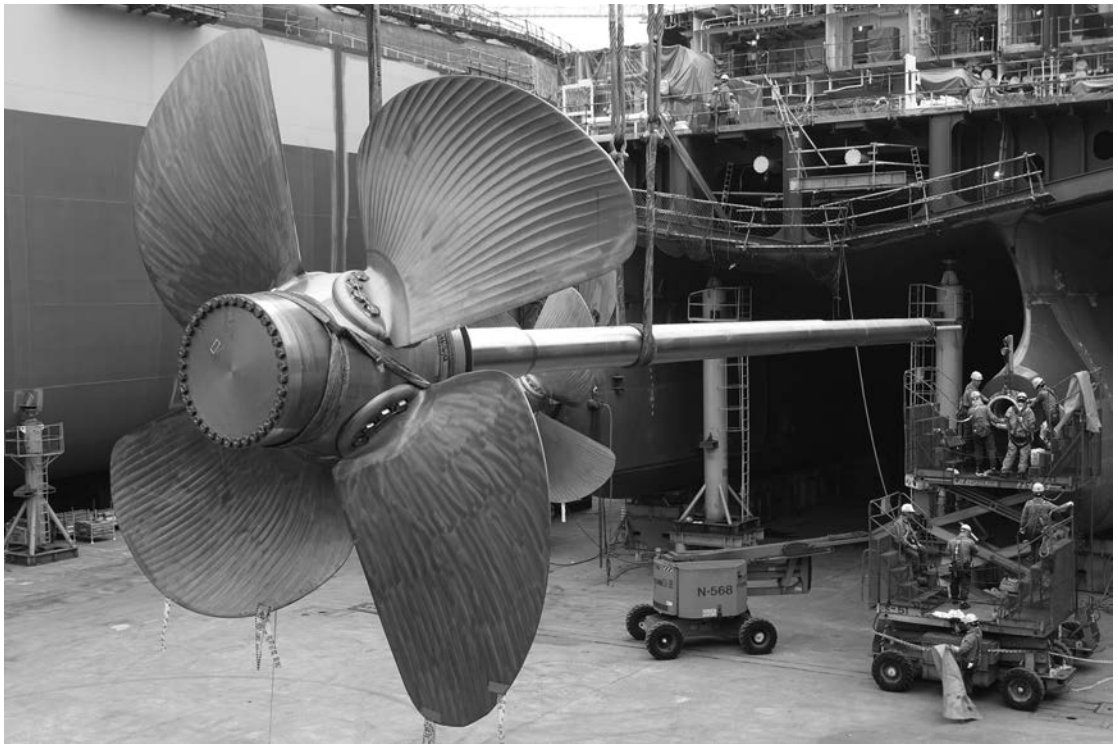
fleets. For Germany's *Deutsche Marine*, integration into an international network of alliances and partnerships has been a consistent theme of naval policy since the recreation of the fleet after the Second World War. However, as explained by distinguished naval analyst Dieter Stockfisch in a maiden contribution to *Seaforth World Naval Review*, recent events are giving impetus to Germany taking more of a leading role in these partnerships, particularly in the Baltic. Meanwhile, Richard Beedall discusses how Britain's Royal Navy is looking to rebuild its worldwide presence as part of a Brexit-related push – termed 'Global Britain' – to expand the United Kingdom's global influence. The big question is whether there are the financial resources available to sustain this ambition at the time of a renewed Russian challenge in home waters.

SIGNIFICANT SHIPS

A key element of the British Royal Navy's ability to sustain a global presence will be its ability to replenish its warships at sea. The civilian-manned Royal Fleet Auxiliary (RFA) service that provides this function has been starved of investment in recent years. However, the arrival of four new 'Tide' class fleet tankers – optimised around supporting the new *Queen Elizabeth* class aircraft carriers – is a significant and positive development. The editor's description of the new ships – which are based on BMT Defence Service's Aegir® evolution of a commercial tanker design to meet a military need – examines the origins and execution of this vital programme. Aegir has also formed the basis for Royal Norwegian Navy's logistic support vessel *Maud*. This project has successfully utilised the same basic design approach to meet a significantly different set of requirements.

An interesting feature of the 'Tide' class programme has been the selection of a South Korean shipyard – Daewoo Shipbuilding & Marine Engineering (DSME) – for the bulk of the new ships' construction and outfitting on the grounds of economy. This has given rise to a degree of controversy, not least because a similar approach may be

The re-emergence of Russian naval power is leading Germany to seek to strengthen its traditional network of maritime partnerships whilst bolstering naval investment. This picture shows one of the five K-130 class corvettes, *Erfurt*, firing a RBS15 surface-to-surface missile during exercises in May 2019; construction of a second batch of five members of the class is now underway. *(German Armed Forces)*



The complicated process of installing the shaftlines on the new British 'Tide' class tanker *Tideforce* at DSME's giant Okpo shipyard in South Korea is depicted in this November 2016 photograph. The respective merits of low-cost offshore construction and supporting a sustainable domestic shipbuilding sector are the subject of debate in many countries. *(Courtesy Shaun Jones)*

adopted for the follow-on project for a new class of fleet solid support (FSS) ships in spite of the availability of surplus British shipbuilding capacity as aircraft carrier construction draws to a close.[6] A very different approach is evidenced in the Indian Navy's acquisition of four Project 28 anti-submarine corvettes. They were intended not only to be built in India but also to use the maximum possible amount of indigenous equipment. As is apparent from Mrityunjoy Mazumdar's article, the lengthy time required to realise a programme first launched in 2003 suggests that the costs involved in sustaining domestic industry are not only financial.

In the third and final article on significant ships, Norman Friedman describes the origins and evolution of the US Navy's *Virginia* (SSN-774) class of nuclear attack submarines, which have now been in service for 15 years. Driven by post-Cold War cost constraints, the class's design team harnessed a range of new technologies to provide an effective and – at least by US Navy standards – affordable submarine that has proved capable of subsequent evolution. The US Navy's FY2019 construction programme saw the transition to the class's fifth, Block V, iteration. The class was initially produced at the rate of just one hull per year and the current year's budget request for three of the type therefore reflects its importance in the current strategic environment.

TECHNOLOGICAL DEVELOPMENTS

Underwater warfare also features heavily in this year's review of technological developments. Complementing his study of the *Virginia* class, Norman Friedman analyses wider developments in submarine design, assessing the likely impact of innovations in the fields of propulsion and autonomy. He concludes that the use of nuclear power is likely to become increasingly attractive for those countries that can afford it. A similar conclusion has been reached by the Brazilian Navy, which is progressing the massive PROSUB programme that is anticipated to see the delivery of an indigenous SN-BR by the early 2030s. Richard Scott's article describes the huge efforts involved in creating the industrial infrastructure required to realise this ambition under a project that is being carried out in collaboration with France's Naval Group. The progress achieved to date is unquestionably impressive. However, a deterioration in Brazil's economic fortunes since the programme commenced has meant there has been insufficient funding available to pursue other naval procurement, resulting in sharp reductions to Brazil's surface navy.

David Hobbs' annual review of world naval aviation completes this year's coverage. With all three variants of the F-35 Lightning II strike fighter in service, he focuses on the opportunities being opened up by the unprecedented situational awareness provided by the new aircraft's combination of sensors and software. The F-35B short take-off and vertical landing (STOVL) variant of the jet also looks set to expand the limited number of navies currently able to deploy fast jets at sea. In September 2018, initial seaborne trials of F-35Bs embarked aboard *Queen Elizabeth* saw the British Royal Navy return to carrier-based jet operations after a gap of nearly eight years. Later, in December, Japan announced its intention to acquire F-35Bs in a move that will see it return to operating fixed-wing aircraft at sea for the first time since the Second World War.

The F-35 Lightning II strike fighter is starting to come of age, with initial operational capability declared on all three land-based, STOVL and carrier variants. This picture shows a F-35B onboard the British carrier *Queen Elizabeth* during night flying trials in November 2018. *(Crown Copyright 2018)*

SUMMARY

The last year has essentially seen the continuation of trends noted in previous editions of *Seaforth World Naval Review*. It is readily apparent that the most prominent of these is the return to great power rivalry and the associated risk of all-out naval combat on the high seas. This, in turn, is forcing many navies to reassess the appropriate weighting of vessels best-suited for high intensity warfighting in their fleets. There is some irony that this reassessment is taking place just as these same fleets are finally taking delivery of a new generation of warships – the likes of Littoral Combat Ships and F125 class stabilisation frigates – purposely designed for lower-intensity operations in the post-Cold War era. The US Navy's FY2020 budget proposal provides some indication of the shift in direction that is taking place. Other navies are likely to follow.

ACKNOWLEDGEMENTS

As *Seaforth World Naval Review* enters its second decade, it continues to benefit from the support of an established team that includes publishing editor Robert Gardiner and designer Steve Dent. John Jordan's excellent illustrations and the outstanding contributions of a diverse range of authors are also enduring features. This edition also includes the photographs and graphics of Derek Fox, Bruno

Huriet, Michael Leek, Marc Piché, Arjun Sarup, Chris Sattler, Haydn Sutton and Devrim Yaylali. From industry, the assistance of BMT's Ancia Barham, Fincantieri's Musella Cristiano, Naval Group's Klara Nadaradjane, and Navantia's Esther Benito Lope has been of particular value. My wife, Susan, continues to demonstrate both patience and resilience in proof-reading the initial draft of my text.

The editor's work has also been aided by regular feedback from readers in the form both of direct contact and published reviews. Whilst it is pleasing much of this is positive, this is inevitably not always the case. In particular, there are three consistent themes that warrant a response:

Colour Photography: At present, 32 of *Seaforth World Naval Review's* 192 pages are printed in colour, a proportion that dissatisfies some readers. In an ideal world, the editor would favour all-colour production. Regrettably, this is inconsistent with the economics of a relatively low-volume publication that has to secure most of its sales within the year-long shelf life of an annual. The use of colour tends to be focused on those chapters where the editor perceives it is of most value, principally in the Significant Ships section.

Minor War Vessels: A number of readers dislike the inclusion of reviews on minor war vessels such as offshore patrol ships, believing the focus should be solely on warfighting units. However, in many regions and in numerous scenarios, it can be argued a lowly patrol vessel is just as influential as a more powerful destroyer or frigate. Moreover, many auxiliary vessels can be essential to the effective performance of even the most potent warships. The 'Tide' class fleet tankers assessed in this year's edition are a case in point. The editor believes these types of vessel need to be included to meet the book's aim of providing balanced coverage across the current naval scene.

The Trump Presidency: A few readers have complained that the book's editorial stance is overtly hostile to the US Trump Presidency. This is not the intention. The Trump administration has been controversial, both domestically and on the international stage. This inevitably has implications for global relations and feeds through to naval developments. The fact that the president is also commander-in-chief of the US Armed Forces, expressing views on matters such as the electromagnetic aircraft launch system (EMALS), also warrants comment.[7] *Seaforth World Naval Review* inevitably has a 'Western' and, more particularly, European world view by nature of its roots. However, the editor's aim is to observe and draw inferences rather than to take a political stance.

US Navy *Independence* variant Littoral Combat Ships *Tulsa* (LCS-16), *Manchester* (LCS-14) and *Independence* (LCS-2) pictured underway in formation in the eastern Pacific in February 2019. A renewed focus on ships required for high intensity oceanic warfighting against near-peer competitors is coinciding with the delivery of vessels designed to meet the needs of operations against less challenging opponents in the littorals. *(US Navy)*

The editor hopes these explanations are of some value and looks forward to further comments and criticisms from readers; please direct them for my attention to: info@seaforthpublishing.com

Conrad Waters, Editor
30 June 2019

Notes:

1. Donald R Coates, *Worldwide Threat Assessment of the U.S. Intelligence Community* (Washington DC: Office of the Director of National Intelligence, 2019) available at: https://www.intelligence.senate.gov/sites/default/files/documents/os-dcoats-012919.pdf

2. See the budget briefing on the US Department of Defense's *Fiscal Year 2020 Budget Request* at: https://comptroller.defense.gov/Portals/45/Documents/defbudget/fy2020/fy2020_Budget_Request.pdf

3. See for example Julian E. Barnes and Helene Cooper, 'Trump Discussed Pulling U.S. From NATO, Aides Say Amid New Concerns Over Russia' posted to the *New York Times* website on 14 January 2019 and currently available at: https://www.nytimes.com/2019/01/14/us/politics/nato-president-trump.html

4. Michael Kofman, 'Russian defense spending is much larger, and more sustainable than it seems', posted on *Defense News* at https://www.defensenews.com/opinion/commentary/2019/05/03/russian-defense-spending-is-much-larger-and-more-sustainable-than-it-seems/

5. See '2018 Annual Defence Report', *Jane's Defence Weekly* – 12 December 2018 (Coulsdon: IHS Jane's, 2018), p.6.

6. A report by the All Party Parliamentary Group on Shipbuilding & Ship Repair published in May 2019 made a particularly strong case for domestic FSS ship construction. See 'All-Party Parliamentary Group for Shipbuilding publish report on the industry' posted to the *Save the Royal Navy* website on 16 May 2019 at https://www.savetheroyalnavy.org/all-party-parliamentary-group-for-shipbuilding-publish-report-on-the-industry/, which includes a link to the report.

7. See for example, Gina Harkins, 'Crazy Electric Catapult Won't Be Used on New Aircraft Carriers, Trump Says' posted to the *Military.com* website on 28 May 2019 at: https://www.military.com/daily-news/2019/05/28/crazy-electric-catapult-wont-be-used-new-aircraft-carriers-trump-says.html

2.1 REGIONAL REVIEW

NORTH AND SOUTH AMERICA

Author:
Conrad Waters

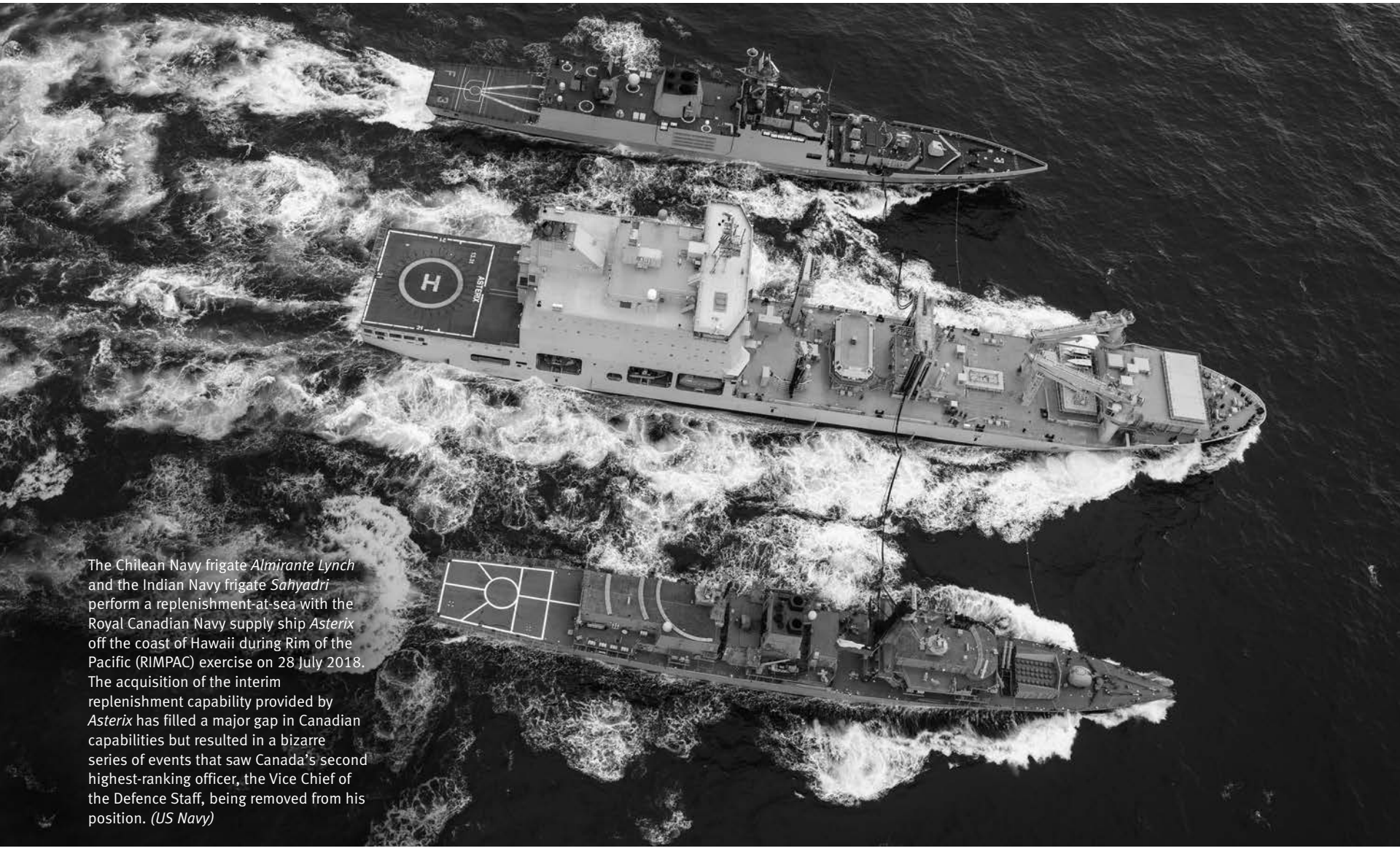
On 28 September 2018, President Donald Trump signed the legislation approving US Department of Defense (DOD) spending appropriations for FY2019. This marked the first time in over a decade that the US military began the new financial year with its funding properly in place. The US$686bn appropriated to the DOD – part of wider defence funding amounting to US$716bn – was largely in line with the Presidential Budget Request submitted the previous February.[1] The settlement was indicative of the continued improvement in the financial fortunes of the US military and, hence, the US Navy as the Trump administration rolls back the austerity of the Obama years.

In spite of a subsequent wobble that saw suggestions the administration was seeking to cut back defence spending to around US$700bn in the year ahead, the good news for the military continued into 2019. The FY2020 Presidential Budget Request released on 11 March proposes headline defence spending of US$750bn, US$718bn of which is allocated to the DOD. This represents a healthy c. five percent uplift year-on-year. Department of the Navy spending is set to grow by US$9.5bn to US$205.1bn. This is broadly in line with that of the overall DOD total. In real terms this returns naval spending to around the level it was a decade ago, before the financial caps of the 2011 Budget Control Act (BCA) started to bite.

There are reasons to believe that the future might not be quite as positive as suggested by these headlines. The balance of power in Congress has shifted away from the presidency. As such, it is by far from clear that this year's budget request will have such an easy ride as previously. This is particularly so given heavy reliance on Overseas Contingency Operations (OCO) funding to circumvent the constraints of the BCA.[2] Even if FY2020's proposed funding is secured, it is difficult to envisage an extended period of further growth given the extent of the American budget deficit. Current official projections over the life of the Future Years Defense Program (FYDP) suggest naval spending will stagnate from FY2021 onwards.

The US Navy therefore faces some real challenges to afford plans to grow from a c. 290-ship to a 355-ship fleet whilst making the necessary investments in new technology required to reverse the recent erosion in its competitive advantage. The FY2020 budget request gave some clues to the trade-offs required to meet these challenges. Fleet growth will slow in the short term as modernisation of some older vessels is cancelled. There also some changes to previously planned acquisitions of some new warships and, particularly, aircraft. The money saved will help pay for a new generation of unmanned vessels which will support a Distributed Maritime Operations concept under which widely dispersed naval units utilise a sophisticated form of cooperative engagement capability (CEC) to track, engage and destroy potential threats.[3] The re-profiling of the shipbuilding and refit programme is also intended to allow a more balanced expansion that will allow the 355-ship target to be achieved and then sustained over the medium term. However, it is possible that a new Force Structure Assessment (FSA) that is currently underway could result in a further shift in targeted fleet numbers and structure when it reports at the end of 2019. It seems likely there will be a change in emphasis towards acquiring larger numbers of small vessels as part of the shift towards distributed operations.

Meanwhile, May 2019 brought a conclusion to a bizarre series of events that had seen Vice Admiral Mark Norman, Canada's Vice Chief of the Defence Staff and former head of the Royal Canadian Navy, removed from his position and charged with breach of trust after a police investigation. The case – which concerned alleged leakage of information relating to the acquisition of an interim replenishment capability through conversion of the container ship *Asterix* to a fleet tanker – was dropped after the prosecution concluded there was 'no reasonable prospect of conviction'. The country's newly-elected Liberal administration had considered abandoning the project after assuming office. However, it had been deterred from that course of action after news of their hesitation had been made public. The effective exoneration of Norman – whose support for the *Asterix* conversion successfully closed a major gap in the navy's capabilities – took place against a backdrop of allegations of political interference that reflects little credit on many in Canada's establishment.[4]



The Chilean Navy frigate *Almirante Lynch* and the Indian Navy frigate *Sahyadri* perform a replenishment-at-sea with the Royal Canadian Navy supply ship *Asterix* off the coast of Hawaii during Rim of the Pacific (RIMPAC) exercise on 28 July 2018. The acquisition of the interim replenishment capability provided by *Asterix* has filled a major gap in Canadian capabilities but resulted in a bizarre series of events that saw Canada's second highest-ranking officer, the Vice Chief of the Defence Staff, being removed from his position. *(US Navy)*

Table 2.1.1: FLEET STRENGTHS IN THE AMERICAS – LARGER NAVIES (MID 2019)

COUNTRY	ARGENTINA	BRAZIL	CANADA	CHILE	COLOMBIA	ECUADOR	PERU	USA
Aircraft Carrier (CVN/CV)	–	–	–	–	–	–	–	11
Strategic Missile Submarine (SSBN)	–	–	–	–	–	–	–	14
Attack Submarine (SSN/SSGN)	–	–	–	–	–	–	–	55
Patrol Submarine (SSK)	2	5	4	4	4	2	6	–
Fleet Escort (CG/DDG/FFG)	4	7	12	8	4	2	7	91
Patrol Escort/Corvette (FFG/FSG/FS)	9	2	–	–	1	6	2	18
Missile Armed Attack Craft (PGG/PTG)	2	–	–	3	–	3	6	–
Mine Countermeasures Vessel (MCMV)	–	4	12	–	–	–	–	11
Major Amphibious Units (LHD/LPD/LPH/LSD)	–	2	–	1	–	–	1	32

Two photographs taken in early May 2019 showing the second Royal Canadian Navy *Harry DeWolf* class Arctic Offshore Patrol Ship, *Margaret Brooke*, completing block assembly at Irving Shipbuilding's Halifax yard. An option for a sixth vessel in the class was exercised in November 2018, whilst two similar vessels are to be built for the Canadian Coast Guard. *(Irving Shipbuilding Inc.)*

MAJOR NORTH AMERICAN NAVIES – CANADA

Away from the unwelcome distraction of the Vice Admiral Norman debacle, Canada has been making progress with the major programme of fleet renewal confirmed under the *Strong*, *Secure*, *Engaged* defence policy published in June 2017.[5] The most important – and expensive – element of this programme is the acquisition of fifteen new Canadian Surface Combatants. They will replace the already retired *Iroquois* class destroyers and current *Halifax* class frigates at an estimated cost of between CAD$55 and CAD$60bn (c. US$42–45bn). The ships are to be built by Irving Shipbuilding in Halifax under the framework established by Canada's National Shipbuilding Strategy. However, in June 2016, it was announced that they would be based on a modified existing design to save time and money. An international competition for design proposals subsequently closed towards the end of 2017.

On 19 October 2018 it was revealed that a proposal from Lockheed Martin Canada based on BAE Systems' Type 26 Global Combat Ship had been identified as the preferred way forward. An initial CS$185m design contract was subsequently awarded to Irving as the programme's prime contractor in February 2019. The Canadian ship will share significant commonality – including its hull form and propulsion system – with the Type 26. However, it will incorporate a variant of the Lockheed Martin CMS 330 combat management system already used in the *Halifax* class and a new active phased array supplied by the company. Other key members of the design consortium include CAE, L3 Technologies, MDA and Ultra Electronics. All have a substantial Canadian presence.[6]

Construction of the Canadian Surface Combatants is not expected to get underway until the early 2020s. This poses questions about the sustainability of the workload at Irving's Halifax yard in the interim. The facility is currently working on the delivery of *Harry DeWolf* class Arctic Offshore Patrol Ships under a contract awarded in January 2015. In November 2018, Canadian Defence Minister Harjit Sajjan announced that a contract option for a sixth member of the class would be taken up, helping bridge the gap until production of the new surface combatants commences. The estimated cost of the programme was increased from CAD$3.5bn to CAD$4.3bn as a result. Subsequently, in May 2019, the yard was allo-

Table 2.1.2: CANADIAN NAVY: PRINCIPAL UNITS AS AT MID 2019

TYPE	CLASS	NUMBER	TONNAGE	DIMENSIONS	PROPULSION	CREW	DATE
Principal Surface Escorts							
Frigate – FFG	**HALIFAX**	12	4,800 tons	134m x 16m x 5m	CODOG, 29 knots	225	1992
Submarines							
Submarine – SSK	**VICTORIA** (UPHOLDER)	4	2,500 tons	70m x 8m x 6m	Diesel-electric, 20+ knots	50	1990

cated the construction of two additional Arctic patrol vessels as part of a wider package of new orders for the Canadian Coast Guard. These are likely to be built to a modified version of the *Harry DeWolf* class design. *Harry DeWolf* herself was floated out on 15 September 2018 prior to a formal naming ceremony the following month. She is expected to be delivered towards the end of 2019. The last year has also seen a keel laying ceremony for the third member of the class, *Max Bernays*, in December 2018. This was followed by the start of construction of the fourth ship, *William Hall*, in May 2019.

The other major beneficiary of the Canadian Coast Guard's renewal programme is Seaspan's Vancouver Shipyards. This is the second designated yard for government shipbuilding contracts for larger vessels under the terms of the National Shipbuilding Strategy.[7] It will be responsible for building sixteen multi-purpose vessels. The yard's main naval programme is for two *Protecteur* class joint support ships based on Germany's Type 702 *Berlin* design, the first of which commenced preliminary construction in 2018. Construction of this lead ship has been accelerated ahead of an oceanographic survey vessel in Seaspan's construction queue. However, a full contract award is not anticipated until 2020 and delivery is scheduled for 2023, two years later than previously planned. Total estimated costs for the two ships now amount to CAD$3.4bn (c. US$2.6bn).

The high cost and sometimes pedestrian implementation of the National Shipbuilding Strategy has resulted in both public criticism and private government deliberations relating to its merits. Recent announcements suggest that Quebec's Davie yard, which successfully delivered the replenishment tanker *Asterix* under Project Resolve and has been contracted to supply interim icebreakers to the coast guard, may be brought into the arrangement as a third force. Davie is already eligible to bid for construction of smaller vessels and for refit work, recently sharing in a CAD$7bn contract to support maintenance of the *Halifax* class pending delivery of their replacements.

Table 2.1.2 shows there has been no significant change in Royal Canadian Navy fleet composition year-on-year. The last year was, however, notable for the final retirement of the veteran CH-124 Sea King helicopter in December 2018 after 55 years of operations. The first of the twenty-eight replacement CH-148 Cyclone helicopters made its first operational deployment embarked in the frigate *Ville de Québec* the previous July.

MAJOR NORTH AMERICAN NAVIES – UNITED STATES

Progress achieved in rebuilding US Navy fleet numbers over the past year has been reflected in an increase in the 'ship battle force' to 290 units as of mid-2019, as set out in more detail in Table 2.1.3. This represented a year-on-year uplift of eight warships and a cumulative fourteen-ship increase over the position in mid-2017. The growth is largely accounted for by deliveries of Littoral Combat Ships. These are now serving in considerable numbers on both the Atlantic and Pacific coasts but have undertaken few operational deployments to date.

Updated plans to achieve the 355-ship target established by the 2016 Force Structure Assessment (FSA) were set out in the mandatory annual report to Congress on the future long-range plan for construction. This was released in March at the time of the presidential budget request.[8] These plans have to be treated with some caution given that the FSA itself will be revised around the end of 2019 to reflect recent strategic guidance but provide an interesting insight into the broad direction of travel of an evolving strategy. In April 2018 it was decided to extend the service lives of all the *Arleigh Burke* (DDG-51) class destroyers to 45 years. In contrast to the position reported last year, this will allow the planned 355-ship objective to be reached during the 2030s and maintained thereafter. However, subsequent decisions have included the proposed cancelling of six planned modernisations of *Ticonderoga* (CG-47) class cruisers and accelerating

Table 2.1.3: US NAVY BATTLE-FORCE DEVELOPMENT (FY2019 TO FY2024)

SHIP TYPE	TARGET	ACTUAL	PLAN					
	FSA	2018	2019	FY2020	FY2021	FY2022	FY2023	FY2024
Aircraft Carrier (CVN)	12	11	11	11 (11)	11 (11)	11 (12)[3]	11 (12)[3]	11 (12)[3]
Strategic Submarine (SSBN)	12	14	14	14 (14)	14 (14)	14 (14)	14 (14)	14 (14)
Attack Submarine (SSGN/SSN)	66	54	55	56 (57)	57 (56)	56 (56)	55 (55)	55 (52)
Fleet Escort: (CG/DDG)	104	88[2]	89[2]	94 (95)	92 (98)	93 (99)	95 (101)	94 (104)
Patrol Escort: (FF/LCS/MCMV)	52	24	29	30 (34)	33 (37)	33 (35)	32 (39)	35 (32
Amphibious Vessel (LHA/LHD/LPD/LSD)	38	32	32	33 (33)	34 (34)	34 (34)	35 (35)	36 (36)
Other – Logistics & Support Ships	71	59	60	63 (64)	64 (64)	70 (68)	72 (70)	73 (71)
TOTAL	**355**	**282**[2]	**290**[2]	**301 (308)**	**305 (314)**	**311 (318)**	**314 (326)**	**314 (321)**

Note

1. Actual numbers are drawn from the Naval Vessels Register for the year in question. Forward data is derived from the *Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for Fiscal Year 2020,* published in March 2019, with comparative data drawn from last year's report
2. These numbers exclude the two *Zumwalt* class destroyers that have been commissioned but have not yet completed combat system installation.
3. Fall reflects the planned withdrawal of the carrier *Harry S. Truman* (CVN-75), which has now been cancelled.

Table 2.1.4: USN FY2020 FIVE YEAR SHIPBUILDING PLAN (FY2020–FY2024)

SHIP TYPE	FY2019 REQUEST	FY2019 FUNDED	FY2020 REQUEST[1]	FY2021 PLAN[1]	FY2022 PLAN[1]	FY2023 PLAN[1]	FY2024 PLAN[1]	FY2020-24 TOTAL FYDP[1]
Aircraft Carrier (CVN-78)	–	–	1 (–)	– (–)	– (–)	– (1)	– (–)	**1 (1)**
Strategic Submarine (SSBN-826)	–	–	– (–)	1 (1)	– (–)	– (–)	1 (1)	**2 (2)**
Attack Submarine (SSN-774)	2	2	3 (2)	2 (2)	2 (2)	2 (2)	2 (2)	**11 (10)**
Destroyer (DDG-51)	3	3	3 (2)	2 (3)	2 (3)	3 (3)	3 (2)	**13 (13)**
Future Frigate (FFG(X))	–	–	1 (1)	2 (1)	2 (2)	2 (2)	2 (2)	**9 (8)**
Littoral Combat Ship (LCS-1/2)	1	3	– (–)	– (–)	– (–)	– (–)	– (–)	**– (–)**
Amphibious Assault Ship (LHA-6)	–	–	– (–)	– (–)	– (–)	– (–)	1 (–)	**1 (1)**
Amphibious Ship (LPD-17 F II)	–	–	– (1)	1 (–)	– (1)	1 (1)	– (1)	**2 (4)**
Expeditionary Fast Transp't (T-EPF-1)	–	1	– (–)	– (–)	– (–)	– (–)	– (–)	**– (–)**
Expeditionary Sea Base (T-ESB-3)	1	1	– (1)	– (–)	– (–)	1 (–)	– (–)	**1 (1)**
Replenishment Oiler (T-AO-205)	2	2	2 (1)	1 (2)	1 (1)	2 (2)	1 (1)	**7 (7)**
Fleet Tug (T-ATS)	1	1	2 (2)	1 (1)	1 (1)	1 (1)	– (–)	**5 (5)**
Surveillance Ship (T-AGOS(X))	–	–	– (–)	– (–)	1 (1)	1 (1)	1 (1)	**3 (3)**
Total	**10**	**13**	**12 (10)**	**10 (10)**	**9 (11)**	**13 (13)**	**11 (11)**	**55 (55)**

Notes
1 Figure in brackets relates to the total of number of ships planned for the same FY2020–24 period at the time of last year's FY2019 budget submission.

Milius (DDG-69) and *Chancellorsville* (CG-62) pictured in company during exercises in the Philippine Sea in March 2019. The US Navy plans to extend the service lives of all its *Arleigh Burke* class destroyers to 45 years but intends to abandon some cruiser modernisations in spite of past Congressional opposition. *(US Navy)*

the withdrawal of *Avenger* (MCM-1) class mine-hunters. This will slow the previously projected rate of fleet growth in the short to medium term, as also reflected in the data contained in Table 2.1.3. In essence, the US Navy appears to be prepared to accept a period of slower, more balanced expansion than previously planned to achieve and sustain its longer term goals.

A particularly controversial element of both the FY2020 budget request and the long-range plan was the proposal to abandon the scheduled refuelling and complex overhaul (RCOH) of the aircraft carrier *Harry S. Truman* (CVN-75). This would have resulted in her being withdrawn from service in the mid-2020s at around the mid-point of her expected service life.[9] In turn, this would have at times reduced the number of operational aircraft carriers to nine compared with the stated FSA requirement of twelve, a decision explained as being in line with the DOD's desire to balance high end platforms with 'complimentary capabilities from emerging technologies'. Although orders for new *Ford* class carriers continue to be placed – a two-ship contract for the third and fourth members of the class was awarded on 31 January 2019 – it seems that the priority previously attached to the US Navy's carrier strike groups is starting to be eroded. In the event, the decision to retire *Truman* was swiftly reversed in the face of stiff Congressional opposition. However, it is difficult to avoid the conclusion that a debate on the future place of the aircraft carrier within the American fleet is now underway.

The five-year FYDP construction programme envisaged by the FY2020 Presidential Budget Request is set out in Table 2.1.4. The total number of fifty-five ships it contains is unchanged from the total envisaged in last year's long-range shipbuilding plan. However, an extra attack submarine and an additional frigate have been substituted for two amphibious ships. There are also some shifts in the timings of acquisitions within the FYDP's five-year timescale. By and large, previous intentions of moving to a steady state construction 'drumbeat' based on orders for two attack submarines, two frigates and two and a half destroyers each year as well as an aircraft carrier every four years are maintained. However, some changes are hidden in the detail. For example, a planned switch to producing a new large surface combatant in the FY2023/FY2024 timescale was not referred to in the plans and subsequent statements have suggested the programme is being

delayed. In similar fashion to the abortive decision to retire *Truman*, this seems reflective of the increasing focus on smaller vessels and unmanned vehicles that is a hallmark of the new Distributed Maritime Operations concept referred to in the Introduction.[10]

Details of main developments with respect to principal fleet constituents are set out below, with summary data provided in Table 2.1.5.

Aircraft Carriers: The last year has seen the US Navy's latest aircraft carrier *Gerald R. Ford* (CVN-78) back in her builders' hands for her 'post shakedown availability'. This is essentially a scheduled period of maintenance and modernisation to iron out the various teething issues discovered during post-delivery testing. These defects appear to have been more extensive than initially envisaged, extending to the need to overhaul some of her steam turbines and put her weapons elevators into an oper-

The US Navy's latest aircraft carrier *Gerald R. Ford* (CVN-78) has spent the last year in dockyard hands for scheduled maintenance and modernisation following post-delivery testing. She will return to the fleet in the autumn of 2019. *(US Navy)*

Table 2.1.5: UNITED STATES NAVY: PRINCIPAL UNITS AS AT MID 2019

TYPE	CLASS	NUMBER	TONNAGE	DIMENSIONS	PROPULSION	CREW	DATE
Aircraft Carriers							
Aircraft Carrier – CVN	**FORD** (CVN-78)	1	100,000 tons+	333m x 41/78m x 12m	Nuclear, 30+ knots	4,600	2017
Aircraft Carrier – CVN	**NIMITZ** (CVN-68)	10	101,000 tons	333m x 41/78m x 12m	Nuclear, 30+ knots	5,200	1975
Principal Surface Escorts							
Cruiser – CG	**TICONDEROGA** (CG-47)	22	9,900 tons	173m x 17m x 7m	COGAG, 30+ knots	365	1983
Destroyer – DDG	**ZUMWALT** (DDG-1000)	2[1]	15,800 tons	186m x 25m x 8m	IEP, 30+ knots	175	2016
Destroyer – DDG	**ARLEIGH BURKE** (DDG-51) – Flight II-A	39	9,400 tons	155m x 20m x 7m	COGAG, 30 knots[1]	320	2000
Destroyer – DDG	**ARLEIGH BURKE** (DDG-51) – Flights I/II	28	8,900 tons	154m x 20m x 7m	COGAG, 30+ knots	305	1991
Littoral Combat Ship – FS	**FREEDOM** (LCS-1)	8	3,500 tons	115m x 17m x 4m	CODAG, 45+ knots	‹50[2]	2008
Littoral Combat Ship – FS	**INDEPENDENCE** (LCS-2)	10	3,000 tons	127m x 32m x 5m	CODAG, 45+ knots	‹50[2]	2010
Submarines							
Submarine – SSBN	**OHIO** (SSBN-726)	14	18,800 tons	171m x 13m x 12m	Nuclear, 20+ knots	155	1981
Submarine – SSGN	**OHIO** (SSGN-726)	4	18,800 tons	171m x 13m x 12m	Nuclear, 20+ knots	160	1981
Submarine – SSN	**VIRGINIA** (SSN-774)	17	8,000 tons	115m x 10m x 9m	Nuclear, 25+ knots	135	2004
Submarine – SSN	**SEAWOLF** (SSN-21)	3[3]	9,000 tons	108m x 12m x 11m	Nuclear, 25+ knots	140	1997
Submarine – SSN	**LOS ANGELES** (SSN-688)	31	7,000 tons	110m x 10m x 9m	Nuclear, 25+ knots	145	1976
Major Amphibious Units							
Amph. Assault Ship – LHD	**AMERICA** (LHA-6)	1	45,000 tons	257m x 32/42m x 9m	COGAG, 20+ knots	1,050	2014
Amph Assault Ship – LHD	**WASP** (LHD-1)	8[4]	41,000 tons	253m x 32/42m x 9m	Steam, 20+ knots	1,100	1989
Landing Platform Dock – LPD	**SAN ANTONIO** (LPD-17)	11	25,000 tons	209m x 32m x 7m	Diesel, 22+ knots	360	2005
Landing Ship Dock – LSD	**WHIDBEY ISLAND** (LSD-41)	12[5]	16,000 tons	186m x 26m x 6m	Diesel, 20 knots	420	1985

Notes:

1 Commissioned but not fully operational pending completion of combat systems installation.

2 Plus mission-related crew.

3 Third of class, SSN-23 is longer and heavier.

4 LHD-8 has many differences.

5 Includes four LSD-49 HARPERS FERRY variants.

John F. Kennedy (CVN-79) received her distinctive island structure at a 'mast stepping' ceremony on 29 May 2019. She was scheduled to be floated out before the end of the year. *(Huntington Ingalls Industries)*

The *Arleigh Burke* Flight IIA destroyer *Paul Ignatius* (DDG-117) pictured on sea trials towards the end of 2018. She was the only member of the class to be delivered to the US Navy in the 1 July 2018 to 30 June 2019 period covered by this annual but orders are now running at the rate of two ships each year. *(Huntington Ingalls Industries)*

ational state. The maintenance period has been extended by around three months in consequence but it seems that some work will still have to be deferred to a later date. This reflects the priority attached to allowing *Ford* to join the active fleet so that subsequent members of the class can benefit from her early operational experience.

Meanwhile good progress continues to be made with the second *Ford* class carrier, *John F. Kennedy* (CVN-79), which received her distinctive island structure at a 'mast stepping' ceremony on 29 May 2019. Construction is reportedly around three months ahead of schedule and she will be floated out in the autumn of 2019 prior to final outfitting. The January 2019 contract for an additional two members of the class – *Enterprise* (CVN-80) and the still to be named CVN-81 – will not accelerate deliveries over previous plans. However, it does provide continuity of production at Huntington Ingalls Industries (HII's) Newport News Yard and also creates significant savings. According to current schedules, *Enterprise* will join the fleet in 2028 and CVN-81 four years later.

Surface Combatants: The US Navy divides its fleet of surface combatants into large surface combatants (cruisers and destroyers) and small surface combatants (frigates and Littoral Combat Ships). Construction of the former continues to be dominated by the *Arleigh Burke* class destroyers. They will remain in production until the transition to the proposed new large surface combatant around FY2025. Orders continue to be split between HII's Ingalls Shipbuilding and General Dynamics' Bath Iron Works (BIW) under a ten-ship, multi-year procurement contract signed in September 2018. This covers the period from FY2018 to FY2022. The agreement allocated US$5.1bn to Ingalls to build both FY2018 destroyers and one ship p.a. subsequently, whilst BIW was awarded US$3.9bn for one ship each year from FY2019 to FY2022. Both contracts included options for additional ships in recognition of the move towards an average 2.5 ship p.a. procurement rate. The lack of FY2018 orders for BIW appears to have reflected the yard's problems in delivering DDG-51 and *Zumwalt* (DDG-1000) class destroyers simultaneously and the need to give it some breathing space to transition to the new DDG-51 Flight III design. However, in December 2018, BIW was awarded the first optional contract – for the third FY2019 destroyer –

granted under the multi-year procurement agreement. This goes some way to redress the gap with its Mississippi rival.

Two of the three BIW-built *Zumwalt* class have now been commissioned. However, both are subject to a split-delivery process that involves an extensive combat systems activation phase following arrival at their homeport of San Diego. As such, neither is yet listed as being part of the fully operational fleet, although final delivery of *Zumwalt* is expected before the end of 2019. The last ship, *Lyndon B. Johnson* (DDG-1002), was floated out on 9 December 2018 prior to christening on 27 April 2019 and expected initial delivery during 2020. There seems to be ongoing uncertainty about the longer term configuration of the class following decisions to abandon the precision munitions intended for their main 155mm Advanced Gun Systems (AGSs) and refocus their mission away from fire support to surface strike. This may even result in their AGSs being replaced by additional vertical launch cells in the fullness of time.[11]

Only one large surface combatant – the destroyer *Paul Ignatius* (DDG-117) – has actually been delivered over the past twelve months. This contrasts with the arrival of five new small surface combatants – the *Freedom* (LCS-1) variant Littoral Combat Ships *Sioux City* (LCS-11), *Wichita* (LCS-13) and *Billings* (LCS-15) and their *Independence* (LCS-2) variant counterparts *Charleston* (LCS-18) and *Cincinnati* (LCS-20). The US Navy has now awarded contracts for the six Littoral Combat Ships authorised in the FY2018 and FY2019 programmes. Four of the six are the Austal USA-manufactured *Independence* type. Assuming no additional units are approved before orders transition to the new FFG(X) frigate, this will leave the US Navy with a total of sixteen LCS-1 variants and nineteen LCS-2 types.

The first FFG(X) frigate will be ordered in the course of FY2020, with a total of twenty ships eventually planned. As compared with the modular Littoral Combat Ships, the FFG(X) is intended to be a multi-mission warship incorporating an area air-defence capability and with a greater capacity for independent, oceanic deployment. In similar fashion to the approach adopted for the Canadian Surface Combatant, the US Navy is seeking to modify an existing design to meet the requirement.

To this end, five companies were each awarded US$15m contracts in February 2018 to evolve existing 'parent designs' – ships that have already been constructed and served at sea – to form the basis of a subsequent bid for the new class. Lockheed Martin, which proposed a *Freedom* frigate adaptation of its LCS-1 design, subsequently dropped out of the competition but the others remain. Two – General Dynamics BIW and Fincantieri – are proposing solutions based, respectively, on Spain's F-100 and Italy's FREMM frigates. Austal USA is advocating an evolution of its LCS-2 variant whilst HII has remained tight-lipped on its own design. A final request for proposals was released in June 2019 with final selection likely in the first half of 2020. The new frigates will utilise equipment developed for other US Navy programmes. This includes the COMBATSS-21 combat management system, the Raytheon Enterprise Air Surveillance Radar (EASR) and a 32-cell Mk 41 vertical launch system.

Amphibious and Support Shipping: The last year has seen stability for US Navy's major amphibious vessels, with no deliveries or departures. However, the second *America* (LHA-6) class amphibious assault ship, *Tripoli* (LHA-7), is now close to completion at HII's Ingalls yard. She is likely to be delivered around the end of the year prior to commissioning in early 2020. Work on the third member of the class, *Bougainville* (LHA-8), commenced in October 2018 prior to a formal keel-laying ceremony on 14 March 2019. Scheduled for delivery in 2024, she differs from her two sisters in incorporating a well deck to house amphibious assault craft. She will also have a larger flight deck that is better-suited to F-35B Lightning II and V-22 Osprey operations.

2019 has also seen HII receive a contract for a second new amphibious ship variant. On 26 March 2019, the yard announced it had signed a US$1.47bn deal to build the first LPD-17 Flight II amphibious transport dock, the as yet unnamed LPD-30. Intended to replace the *Whidbey Island* (LSD-41) and *Harper's Ferry* (LSD-49) dock landing ships, the new class is somewhat simpler and more cost-effective than the earlier Flight Is. The yard is currently building the twelfth and thirteenth ships of this previous flight, with *Richard M. McCool Jr.* (LPD-29) joining *Fort Lauderdale* (LPD-28) in production in

Increasing numbers of Littoral Combat Ships are now being delivered from the two shipyards building the different variants. This December 2018 shows *Billings* (LCS-15), *Indianapolis* (LCS-17) and *St. Louis* (LCS-19) in various stages of construction at the Marinette Marine yard in Wisconsin. *Billings* was subsequently handed over to the US Navy in January 2019. *(US Navy)*

July 2018. Existing FSA plans call for thirty-eight amphibious ships: twelve amphibious assault ships and twenty-six amphibious transport docks and/or dock landing ships. However, the FY2020 budget request slowed planned future procurement in spite of a material numerical shortfall.

Part of this gap has been covered by the innovative use of cheaper, second-line amphibious ships derived from commercial designs. These are typically crewed by civilian mariners of the US Military Sealift Command. Most numerous are the expeditionary fast transports – the former Joint High Speed Vessels – that are built alongside the *Independence* (LCS-2) class by Austal USA. March 2019 saw contracts agreed for the 13th and 14th members of class following a Congressional 'mark-up' for an additional, probable final vessel, in the FY2019 defence authorisations. The larger expeditionary transfer docks (ESDs) and expeditionary mobile bases (ESBs) have also proved successful. Two of each type now in service. Completion of a third ESB, *Miguel Keith* (T-ESB-5), has been set back by the accidental flooding of her dock in July 2018 whilst under construction at General Dynamics' NASSCO facility in San Diego, California. She finally commenced initial trials in June 2019.

Meanwhile, progress is being made with a trio of lower-profile programmes focused on the amphibious craft and vehicles that remain essential to US Marine Corps operations. The most significant of these is that for the ship-to-shore connector (SSC). This is a replacement for the hovercraft-like landing craft air cushion (LCAC) embarked in a number of amphibious warships. Designed 'in house' by the US Navy and built by Textron, the SSC is essentially an evolution of the LCAC with improved propulsion and controls. A prototype commenced testing in the first half of 2018 and initial operational capability is anticipated to be achieved before the end of 2020. Contracts have also now been let for the first three units of a new series of LCU-1700 utility landing craft. Again, these are an evolution of an existing design, in this case of the 1950s-era LCU-1610. They are effectively complimentary SSCs, being capable of carrying greater payloads at longer ranges but with far less speed. Construction is being undertaken by Swiftships of Louisiana, which could build over thirty of the type if all options are exercised. Completing the trio is the Corps' new amphibious combat vehicle (ACV), a replacement of the 40-year old AAV amphibious assault vehicle. Contracted to BAE Systems in June 2018, the new ACV – based on an Italian IVECO design – has performed well during prototype testing. It is likely to enter full production during the next twelve months.

Submarines: The US Navy continues to focus on expanding the capacity of its submarine industrial base as it moves towards starting assembly of its next generation *Columbia* (SSBN-826) class strategic submarines. Preliminary fabrication work on these new submarines is already underway under advanced funding arrangements. Authorisation for procurement of the first boat is expected during FY2021.

Construction of the new submarines continues to represent a significant challenge for American industry. As recently as FY2010, US Navy submarine orders were limited to just one *Virginia* (SSN-774) class boat each year. This will expand to as many as three submarines each year during the late 2020s and 2030s. General Dynamics Electric Boat president Jeff Geiger has equated this to the industrial base needing to expand its output by 250 percent in the period of peak production to meet the increased demand.[12] Mr Geiger was speaking following the allocation of US$500m to the company to direct towards supporting sub-contractor stability and achieving economic efficiencies based on production economies for major components. General Dynamics Electric Boat is the prime contractor for the programme. It is sharing work with America's other submarine builder, HII's Newport News yard, on an approximate 80/20 basis.

Deliveries of *Virginia* class attack submarines are now running at two p.a. but are still encountering some slippage against planned delivery dates as the navy attempts to speed production. Construction of the eight Block III submarines is now almost complete with only *Delaware* (SSN-791) still to be delivered. Construction of the first Block IV submarine, *Vermont* (SSN-792), is also well advanced and she should be delivered during the next twelve months. The US Navy had been hoping that this block could be completed in between 60 and 62 months but now accept that a 66-month timescale – similar to that achieved for the Block IIIs – is more realistic.[13] The submarines authorised from FY2019 will be built to the new Block V specification and many will incorporate the Virginia Payload Module

The US Navy has been investing in a number of cost-effective, second-line amphibious ships evolved from commercial designs. Most are operated by civilian mariners of the US Military Sealift Command but the expeditionary mobile base *Lewis B. Puller* (ESB 3) – seen here in the Arabian Sea in 2018 – has been commissioned as a US Navy warship due to the nature of some of the operations she is involved with in the Middle East. *(US Navy)*

(VPM) hull plug to expand their missile capacity. Like most of their predecessors, these are to be ordered under a bulk, multi-year procurement but signature of the contract has been seemingly delayed. A more detailed review of the *Virginia* class is contained in Chapter 3.3.

Operational Highlights: The usual 'operational context' slide accompanying the US Navy's FY2020 budget request suggested ninety-one of the navy's ships were deployed as of March 2019. This represented a decline of around ten percent year-on-year in spite of the slight overall growth in the size of the fleet. The reduction could well reflect the usual difficulties inherent in relying on a 'snapshot' view but other factors may have been in play.

The US Navy has faced an increasing struggle to maintain its fleet during an era of budget caps and the available industrial infrastructure is proving inadequate to catch up with a backlog of repairs and upgrades. This was evident in the inaugural report to Congress on the long-range plan for maintenance and modernisation of the fleet, published in March 2019.[14] There are insufficient dry docks – particularly on the Pacific Coast – to meet the likely level of maintenance required. Many facilities also need substantial investment to be suitable for the next generation of ships. It is clear that the problem is recognised. Substantial investment upgrading the four publicly-owned naval shipyards is being accompanied by attempts to encourage the private yards that perform much of the maintenance work to provide additional capacity. However, the number of deployable ships is currently being impacted as some ships and submarines are being kept waiting for and/or facing extended periods of essential maintenance.[15]

Another factor is the fallout from the collisions and other incidents in mid-2017 that heavily damaged two destroyers and cost the lives of seventeen sailors. Investigations into the collisions have revealed significant deficiencies in the training and understanding of key personnel. These were exacerbated by crewing shortages and punishing operational schedules that – at least in the case of the

A LCU utility landing craft pictured from a US Navy amphibious assault ship. Orders for a new series of LCU-1700 landing craft are one of a series of lower profile but important amphibious acquisitions that are currently being advanced. *(US Navy)*

The lead *Nimitz* (CVN-68) class carrier pictured in Dry Dock 6 at Puget Sound Naval Shipyard in Bremerton, WA in April 2018 during a scheduled overhaul. The US Navy is struggling to deal with a maintenance backlog in the face of inadequate support infrastructure, particularly on the Pacific Coast. *(US Navy)*

Unmanned Systems

A notable aspect of the US Navy's 2020 Budget Request was its focus on unmanned vehicles. It is clear that the US Navy sees such systems – alongside other emerging technologies – as key to meeting the growing challenge from near peer competitors. The briefing on the US Department of Defense's *Fiscal Year 2020 Budget Request* summarised procurement plans for some – but by no means all – these systems over the next five years

US Navy presentations suggest that it organises procurement of unmanned surface vehicles (USVs) into (i) large, (ii) medium, (iii) small, and (iv) very small categories. Procurement of unmanned underwater vehicles (UUVs) is similarly arranged into (i) extra-large, (ii) large, (iii) medium, and (iv) small types. The navy has been developing smaller unmanned systems – that are typically deployed from manned warships and submarines to supplement existing capabilities – for a number of years and in material numbers. However, there has recently been increased focus on the larger types. In contrast to the smaller systems, these are intended for direct deployment from their own bases to perform missions that might otherwise be assigned to manned warships. The large and medium-size USVs and the extra-large UUVs fall into this category.

Budget materials suggest the US Navy plans to allocate US$4.5bn to these larger unmanned vehicles over the next five years, of which US$629m will be spent in FY2020. These programmes can be summarised as follows:

Large Unmanned Surface Vehicle (LUSV): The US Navy plans to acquire ten LSUVs over the next five years at the rate of two p.a. Part of the planned distributed fleet, they are principally intended to add to the fleet's distributed firepower by shipping anti-surface and land attack missiles. Reports suggest they will be between 60m and 90m in length with a displacement of c. 2,000 tons. The first vessels may be optionally manned to ease the new concept into use but semi-autonomous and even fully autonomous capability seems likely. They might act both in concert with manned vessels and fully independently. Requests for information from industry on potential designs have already been issued and these are likely to transition into a full design competition in the course of FY2020.

Medium Unmanned Surface Vehicle (MUSV): The MUSV programme commenced in FY2019 and an order for a prototype is imminent. The vessels are expected to accommodate multiple payloads, although it seems they are principally intended to act as platforms for radar and other surveillance equipment, as well as for electronic warfare. Between 12m and 50m in length, the new vessels are likely to draw heavily on the US Office of Naval Research's (ONR's) autonomous *Sea Hunter* drone.

Extra Large Unmanned Undersea Vehicle (XLUUV): Also known as Orca, this is the most advanced of the large naval unmanned vehicle programmes. Nine vehicles are expected to be procured between FY2020 and FY2024, with Boeing awarded contracts for the first five in February and March 2019. The design will be influenced by Boeing's existing Echo Voyager UUV, a long-range, fully autonomous vehicle equipped with a modular payload section. In addition to acting as a surveillance platform, it seems the US Navy envisages such vessels being equipped with strike and ASW systems over time.

Alongside the procurement of this new technology, the US Navy is also starting to work on developing new organisational and tactical concepts for unmanned systems. In May 2019 it created a Surface Development Squadron 1 (SURFDEVRON) from a squadron previously intended to ease the transition of the new *Zumwalt* class destroyers into the fleet. Initially combining *Zumwalt* with Sea Hunter – and later growing to include the other DDG-1000 destroyers and the new LUSVs and MUSVs – SURFDEVRON will work out how best to employ these systems in a fully operational context.

SELECTED US NAVY UNMANNED SYSTEMS – PLANNED ACQUISITIONS FY2019–FY2024

PROGRAMME	FY2019 FUNDED	FY2020 REQUEST	FY2021 PLAN	FY2022 PLAN	FY2023 PLAN	FY2024 PLAN	FY2020-24 TOTAL FYDP
Unmanned Surface Vessels							
Large Unmanned Surface Vessel (LUSV)	–	2	2	2	2	2	**10**
Medium Unmanned Surface Vessel (MUSV)[1]	1	–	–	–	1	–	**1**
Unmanned Undersea Vehicles							
Extra Large Unmanned Undersea Vehicle (XLUUV)	–	2	2	1	2	2	**9**
Large Diameter Unmanned Undersea Vehicle (LDUUV)	–	–	1	–	2	–	**3**
Small/Medium Unmanned Undersea Vehicle	8	8	12	8	6	10	**44**
Unmanned Aerial Vehicles							
MQ-4C Triton UAS	3	2	2	3	5	5	**17**
MQ-25 Stingray	0	0	0	0	4	4	**8**
MQ-9A Reaper (USMC)	0	3	3	0	0	0	**6**

Note: 1. Not included in the 2020 US Navy Budget Briefing Summary but reported in other sources.

destroyer *Fitzgerald* – meant that some key navigational aids were not fully functional. The result has been a push back against a previous 'can do' approach that is reducing situations where ships are sent on deployments before they are properly ready.[16]

Irrespective of this more cautious approach, the US Navy remains heavily challenged by the demands posed by emerging near-peer competitors when the ongoing war against terror still demands resources and the situation in the Middle East remains particularly unstable. Whilst the Indo-Pacific Command remains the top priority in view of continuing Chinese expansionism, there has been a pattern of evolving naval deployments across the globe. For example, 2018 saw the *Truman* strike group conducting carrier-based exercises north of the Arctic Circle for the first time since the Soviet Union's collapse in an attempt to add an element of unpredictability to the normal pattern of operations. The carrier's expected place in the Middle East was taken by the *Essex* amphibious ready group. It included a small embarked force of F-35B strike fighters that undertook their inaugural combat missions. Increasing tensions with Iran over the belief it has been behind a number of unattributed attacks on merchant shipping have subsequently seen additional US forces dispatched to the area. The destruction of a US Navy RQ-4 surveillance drone by an Iranian Revolutionary Guard Corps surface-to-air missile on 20 June 2019 has added a further element of risk to an already dangerous situation.

US Coast Guard: The US Coast Guard's budget request for FY2020 amounted to US$11.3bn. This is around US$1bn less than that authorised in FY2019. The amount has been criticised as being inadequate to sustain headway with key modernisation programmes, which have been making good progress. In practice, Congress has frequently boosted Coast Guard funding during the legislative process. There are therefore reasons to believe the final settlement may be more generous than that indicated in the budget figures.

In the meantime, the Coast Guard continues to receive new ships ordered in previous financial years. Eight of the 'Legend' or *Bertholf* (WMSL-750) class national security cutters have now been delivered following receipt of *Kimball* (WMSL-756) and *Midgett* (WMSL-757) from HII in September 2018 and May 2019 respectively.

A live fire exercise involving the US Navy destroyer *Chung Hoon*'s Phalanx CIWS in April 2019. The United States has been bolstering its forces in the region as tensions with Iran escalate. *(US Navy)*

The US Coast Guard's seventh national security cutter *Kimball* (WMSL-756) pictured in the course of sea trials in the Gulf of Mexico. The service has taken delivery of both *Kimball* and her sister *Midgett* (WMSL-757) in the past year. *(Huntington Ingalls Industries)*

A contract for the tenth and eleventh units of this extended class – only eight were initially envisaged – was awarded in December 2018.

Construction of the first of twenty-five of the planned intermediate-size 'Heritage' class offshore patrol cutters began at Eastern Shipbuilding in Panama City, Florida on 7 January 2019 with first steel cutting for *Argus* (WMSM-915). The shipyard received damage from Hurricane Michael in the previous December and there have been some suggestions this might delay the programme. Funding for a second cutter – *Chase* (WMSM-916) – was approved in the FY2019 budget. A third is requested in the current proposals.

Thirty-four of the smaller' Damen Stan patrol 4708 design 'Sentinel' or *Bernard C. Webber* (WPC-1101) class have now been delivered following acceptance of *William Hart* (WPC-1134) from Bollinger in May 2019. The FY2020 budget request includes funding for two additional vessels. These will be the 57th and 58th members of the class, nominally meeting the stated requirement for homeland security. However, four of these are destined for service in the Persian Gulf and therefore not counted in the total, meaning additional orders are likely.[17]

The last year has also seen a start on the new polar security cutter programme with the award of a US$746m contract to VT Halter Marine on 7 May 2019 for the first of a planned class of three heavy icebreakers. The c. 23,000-ton vessel is based on the German *Polar Stern II* design and will be provided with a diesel-electric propulsion system incorporating a central shaft and azimuth thrusters. She is expected to be delivered in 2024 and will be followed by two additional sister-ships if contract options are exercised. The Coast Guard also has plans for three medium icebreakers in a major recapitalisation of its polar capabilities.

OTHER NORTH AND CENTRAL AMERICAN NAVIES

Elsewhere in North and Central America, only **Mexico's** navy is of real note. Its modernisation took another step forward on 23 November 2018 with the performance of the launch and initial flag raising ceremony for new *Patrullera Oceánica de Largo Alcance* (POLA) *Reformador*, a light frigate based on the Dutch Damen 'Sigma' 10514 design. The most sophisticated warship built in a Mexican yard to date, she marks a transition from a focus on the construction of purely constabulary assets to the indigenous assembly of ships with warfighting potential. Delivery of the c. US$450m ship is expected by the end of 2020.

The Mexican Navy fared relatively well under the presidency of Enrique Peña Nieto, being bolstered by the arrival of eight *Tenochtitlan* class (Damen Stan Patrol 4207) inshore patrol vessels and two larger *Oaxaca* class offshore patrol ships. A further two of the latter type are under construction. The navy would now like to build on this progress by procuring a total of eight of the *Reformador* class. These would replace its aging former US Navy frigates and form homogeneous four-ship squadrons on each coast. However, this will inevitably depend on the policies adopted by the new administration of President Andrés Manuel López Obrador, who assumed office on 1 December 2018.

The smaller navies in Central America and the Caribbean continue to be structured around smaller patrol and logistic support vessels. The Damen Stan Patrol 4207 used by Mexico is proving increasingly popular across the region, with the Bahamas, Barbados, Honduras and Jamaica also amongst navies and coast guards also operating the type. The most recent regional users are **Nicaragua** and the small island nation of **St. Vincent & the Grenadines**. Both nations commisisoned former Jamaican vessels in early 2019. **Jamaica** had previously traded-in three of the type for two new vessels in 2016, with Damen refurbishing the ships in the Netherlands before offering them for resale through Damen Trading. The former *Cornwall* and *Surrey* have become the Nicaraguan Naval Force's *Sovereignty I* and *Sovereignty II*, whilst the previous *Middlesex* is now the St Vincent and the Grenadines Coast Guard's *Captain Hugh Mulzac.* A number of other naval forces in the region operate Damen Stan Patrol designs of various types.

MAJOR SOUTH AMERICAN NAVIES - BRAZIL

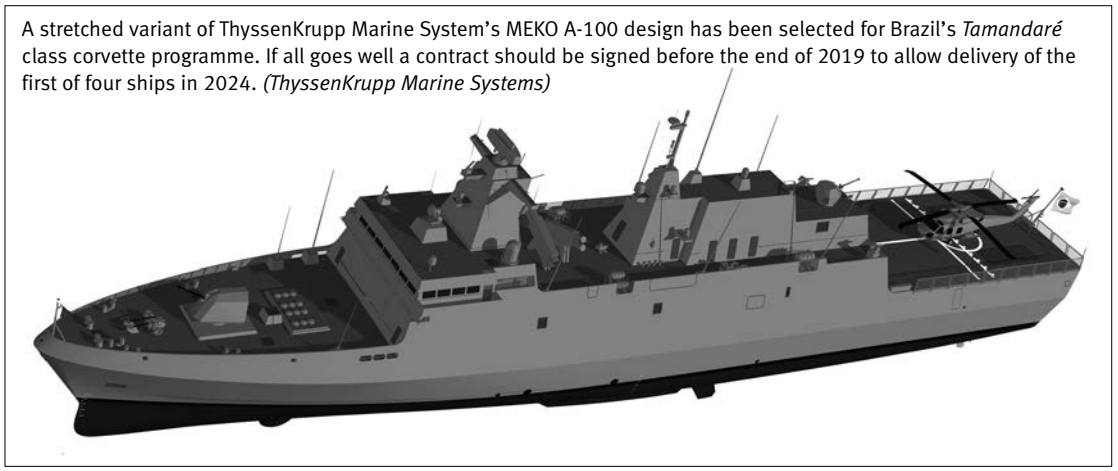
Naval construction in Brazil continues to be dominated by the huge PROSUB submarine programme, which is assessed in detail in Chapter 4.3. Whilst the project is making good progress, the substantial funds devoted to the project have curtailed invest-

The Mexican Navy's new 'Sigma' 10515' type light frigate *Reformador* saw her initial flag-raising ceremony on 23 November 2018. However, it will not be until 2020 that she is ready to enter operational service. *(Mexican Navy)*

ment in other naval programmes at a time when the Brazilian economy has experienced a period of prolonged under-performance. With new President Jair Bolsonaro apparently struggling to turn the economic situation around, the financial position remains problematic.

The result of this difficult situation is reflected in Table 2.1.6, which demonstrates the continued contraction of the surface fleet. This has seen the formal decommissioning of the lead *Niterói* class frigate on 28 June 2019, with the *Inhaúma* class corvette *Jaceguai* set to follow before the end of September. As only three of the *Niterói* class are scheduled to receive further upgrades to their combat systems and the two remaining Type 22 frigates also slated for retirement soon, the navy could be reduced to a flotilla of just four or five major surface combatants within the next few years.

The major hope of improving the situation rests with the evolving plan to construct a quartet of *Tamandaré* class corvettes, effectively a replacement for the much more ambitious PROSUPER fleet renewal programme. On 28 March 2019 it was announced that the Águas Azuis consortium consisting of ThyssenKrupp Marine Systems, Embraer Defense & Security and Atech was the preferred bidder for the contract. The new ships – effectively light frigates – will be based on the MEKO A-100 design. Displacing around 3,500 tons, the 107.2m long vessels will be armed with Exocet surface-to-surface and Sea Ceptor surface-to-air missiles. They are reported to incorporate a package of sensors that includes BAE Systems' Artisan and Thales' STIR radar, as well as an Atlas Elektronik ASO 713 hull-mounted sonar. In a change to previous plans, construction will be carried out at Estaleiro Oceana in Itajaí, southern Brazil. If all goes to plan – by no means certain given Brazil's economic difficulties – a contract will be formalised by the end of 2019 to allow delivery of the first ship in 2024.



A stretched variant of ThyssenKrupp Marine System's MEKO A-100 design has been selected for Brazil's *Tamandaré* class corvette programme. If all goes well a contract should be signed before the end of 2019 to allow delivery of the first of four ships in 2024. *(ThyssenKrupp Marine Systems)*

Press reports suggest that the Brazilian Navy has a number of other pending projects that it would like to commence soon. These include acquisition of two former Swedish *Landsort* class minehunters and the restart of construction of smaller patrol vessels, the latter to be based on the new NPa500BR design. Again, economic difficulties may well forestall these ambitions.

Meanwhile, the arrival of the new helicopter carrier *Atlântico* – the former British Royal Navy *Ocean* – in August 2018 has allowed the formal decommissioning of the aircraft carrier *São Paulo*, which had not been operational for several years. The former French *Foch* acquired in November 2000, she had spent a grand total of just 206 days at sea and sailed fewer than 54,000 nautical miles in the eighteen years that elapsed before the decommissioning ceremony, which was held on 22 November 2018.[18] A handful of her AF-1 and AF-1A Skyhawk aircraft – recently modernised by Embraer – are being maintained in service in the hope of maintaining a cadre of fast jet pilots until fixed-wing aviation can be revived.[19]

OTHER SOUTH AMERICAN NAVIES

The last year has seen **Argentina's** navy experience somewhat better fortunes following the tragic loss of the TR-1700 class submarine *San Juan* in November 2017. The boat's wreck was found by US-based contractor Ocean Infinity almost a year to the day since the submarine was lost using autonomous underwater vehicles deployed from the offshore

Table 2.1.6: BRAZILIAN NAVY: PRINCIPAL UNITS AS AT MID 2019

TYPE	CLASS	NUMBER	TONNAGE	DIMENSIONS	PROPULSION	CREW	DATE
Principal Surface Escorts							
Frigate – FFG	**GREENHALGH** (Batch I Type 22)	2	4,700 tons	131m x 15m x 4m	COGOG, 30 knots	270	1979
Frigate – FFG	**NITERÓI**	5	3,700 tons	129m x 14m x 4m	CODOG, 30 knots	220	1976
Corvette – FSG	**BARROSO**	1	2,400 tons	103m x 11m x 4m	CODOG, 30 knots	145	2008
Corvette – FSG	**INHAÚMA**	1	2,100 tons	96m x 11m x 4m	CODOG, 27 knots	120	1989
Submarines							
Submarine – SSK	**TIKUNA** (Type 209 – modified)	1	1,600 tons	62m x 6m x 6m	Diesel-electric, 22 knots	40	2005
Submarine – SSK	**TUPI** (Type 209)	4	1,500 tons	61m x 6m x 6m	Diesel-electric, 22+ knots	30	1989
Major Amphibious Units							
Helicopter Carrier – LPH	**ATLÂNTICO** (OCEAN)	1	22,500 tons	203m x 35m x 7m	Diesel, 18 knots	490	1998
Landing Ship Dock – LSD	**BAHIA** (FOUDRE)	1	12,000 tons	168m x 24m x 5m	Diesel, 20 knots	160	1998

support vessel *Seabed Constructor*. The submarine had imploded in an underwater ravine at a depth of some 920m. Whilst there has been some pressure from families of lost crew members to raise the wreck, a definitive conclusion on the causes of the accident may never be reached.

San Juan's loss has left the Argentine Navy without an operational submarine capability. Sister boat *Santa Cruz* is currently under extended refit whilst the older 1970s-era Type 209 *Salta* has too many defects to be deployed. Recent reports suggest that Brazil may come to the rescue by the transfer of two of its own *Tupi* class Type 209 submarines, which will soon be replaced by the new 'Scorpène' type boats of the *Riachuelo* class. If Argentina can find the money to finance the purchase, the submarines could be transferred within the next twelve months. A further pair could follow at a later date as more Brazilian 'Scorpènes' enter service.

In the interim, tangible progress has been made with the renewal of Argentina's offshore patrol capability with the conclusion of lengthy negotiations to acquire four OPV90 *L'Adroit* type vessels from France's Naval Group. A €319m (c. US$360m) contract was signed in November 2018. This encompasses both the existing *L'Adroit* and three new-build vessels, which will be constructed under the Kership alliance with Concarneau-based Piriou. It is anticipated *L'Adroit* will be delivered before the end of 2019, with the three new ships being delivered at annual intervals between 2020 and 2022.

Concluding a year-long celebration of its bicentennial in 2018, **Chile's** navy remains one of Latin America's best-funded and well-equipped fleets. In October 2018, the navy was given the green light to begin finding replacements for its two Dutch 'L' or *Jacob van Heemskerck* class air-defence ships, *Almirante Latorre* and *Capitán Prat*, and its sole Type 22 frigate *Almirante Williams* (the former British Royal Navy *Sheffield*). There is some enthusiasm for undertaking a local construction programme at ASMAR's Talcahuano yard. However, relatively short timescales suggest that a purchase of surplus second-hand units is more likely. Discussions to add a further pair of 'M' or *Karel Doorman* class frigates to the two already operated have already been held with the Royal Netherlands Navy. However, recent reports suggest that acquisition of Australia's youngest FFG-7 type *Adelaide* class frigates might be the preferred option. These would provide an area air defence capability through their SM-2 missiles and are more immediately available.

Whilst ASMAR might eventually become involved in future frigate construction, its current focus is building the new 'Vard 9-203' type icebreaker *Antártica 1*. Construction formally got underway at a ceremony held on 16 August 2018 and delivery is anticipated to take place before the end of 2021. Reports suggest the ship is the first ever icebreaker to be built in the southern hemisphere. The ship it will replace, the veteran Canadian-built *Almirante Oscar Viel*, has already been withdrawn from service after a decommissioning ceremony at Talcahuano on 11 February 2019.

Peru and **Colombia** are two other navies that are making progress in developing an indigenous naval shipbuilding capability. Peru's SIMA delivered its first *Makassar* type amphibious dock, *Pisco*, in June 2018 and is now focused on completing the second vessel of the class, *Paita*. It has also continued construction of the South Korean-designed *Río Pativilca* class coastal patrol vessels for the coast guard, holding a keel-laying ceremony for the fifth and sixth units, *Río Tumbes* and *Río Locumba*, in March 2019. Meanwhile, Colombia's COTECMAR has been delivering a series of offshore patrol vessels based on Fassmer's OPV80 design, as well as constructing the indigenous BAL-C/BDA logistic landing ships. The latest to be delivered is *Bahía Colombia*, which was commissioned on 23 July 2018. Displacing c. 600 tons, these 49m vessels are well suited for logistical support and humanitarian operations in underdeveloped coastal regions. One has already been exported to Honduras. In the longer term, both SIMA and COTECMAR also hope to be involved in frigate replacement programmes for their respective navies. There has, however, been little news of these projects over the last year.

Elsewhere in Latin America, refurbishment and modernisation of older vessels seems to be the order of the day. **Ecuador** has reported the return to service of three of its six *Esmeraldas* class corvettes after completion of a four year long refurbishment programme by local yard ASTINAVE. **Venezuela** is also attempting to make some progress making laid-up frigates and submarines fit for sea. However, the country's ongoing political and financial crisis suggests that state-owned shipyard DIANCA will continue to struggle to complete the work. At present, it seems only one of the six *Mariscal Sucre* (*Lupo*) class frigates is partly operational and both Type 209 submarines are docked for repairs. Many other ships are suffering from defects or lack of spare parts that will not be resolved whilst American and European sanctions hold.[20]

The Ecuadorian Navy's newly modernised *Esmeraldas* class corvette *Los Ríos* pictured from the Peruvian Navy frigate *Bolognesi* in the course of the UNITAS 18 exercises in September 2018. *Los Ríos* is one of three refurbished ships of the class that Ecuador has returned to service over the past year. *(Peruvian Navy)*

Notes:

1. The United States' financial year runs from 1 October to 30 September. A budget request for the next year is normally submitted for Congressional approval in February or March. The following months are subject to considerable horse-trading as various political interests attempt to influence the details of the spending that is actually authorised. The DOD budget does not represent the country's entire military spending because some substantial defence expenditure is incurred within other departments, principally the Department of Energy's nuclear programmes.

2. As explained in previous editions of *Seaforth World Naval Review*, OCO funding is supposed to be used to support essential warfighting costs incurred over and above normal defence spending. As such, it is outside the usual spending caps imposed by the 2011 Budget Control Act in an effort to control the large US deficit. However, OCO has been increasingly allocated to normal DOD spending to circumvent BCA restrictions, the FY2020 budget request seemingly taking this subterfuge to a new level. US$164bn of the total US$718bn DOD budget relates to OCO, of which US$98bn is explicitly stated as being linked to base spending requirements. It is unclear whether Congress will continue to tolerate this mechanism. For example, see Mark Cancian's 'The Pentagon's 2020 Budget Could Be Collateral Damage In Trump's Battles With Congress' posted to the *Forbes* website on 12 March 2019 at: https://www.forbes.com/sites/markcancian/2019/03/12/trumps-fy-2020-budget-will-defense-be-collateral-damage/#2418c5131365

3. An excellent explanation of the background to and likely implementation of the Distributed Maritime Operations concept is provided by Kevin Eyer and Steve McJessy in an article entitled 'Operationalizing Distributed Maritime Operations' posted to the *Center for International Maritime Security* website on 5 March 2019 at: http://cimsec.org/operationalizing-distributed-maritime-operations/39831

4. A good overview of the Norman affair is provided by David Pugilese in '"The fight of your life": In a Postmedia exclusive, Mark Norman tells his side of the story' posted to the *Ottawa Citizen*'s website on 21 May 2019 at: https://ottawacitizen.com/news/politics/the-fight-of-your-life-in-a-postmedia-exclusive-mark-norman-tells-his-side-of-the-story/wcm/775bc859-4b0c-451c-acb6-8adb85e3103c

5. See Strong, *Secure, Engaged: Canada's Defence Policy* (Ottawa: Department of National Defence, 2017) at: dgpaapp.forces.gc.ca/en/canada-defence-policy/docs/canada-defence-policy-report.pdf

6. The winning Lockheed Martin Canada-led design team maintain a Canada's Combat Ship Team website at: http://canadascombatshipteam.com/

7. First launched in 2010, Canada's National Shipbuilding Strategy aimed to rebuild a stable and reliable indigenous maritime sector by channelling construction of larger government-owned vessels – those displacing over 1,000 tonnes – through two pre-selected yards. Subsequently, in October 2011, east-coast Irving Shipbuilding Inc. was chosen to build future naval combatants and west-coast Seaspan allocated a less costly package of non-combatant vessels.

8. *Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for Fiscal Year 2020* (Washington DC: Office of the Chief of Naval Operations, 2019). Analysis on the current state of these plans and the issues surrounding them can be found in Ronald O' Rourke's *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress RL32665* (Washington DC: Congressional Research Service, 2019). Like many of Mr O'Rourke's other periodically updated reports, this has been posted as a public service on the Federation of American Scientist's website at: fas.org/sgp/crs/weapons/

9. This is not the first time such a potentially wasteful measure has been considered. Cancellation of the RCOH of *George Washington* (CVN-73) was proposed during the Obama administration to help deal with the impact of Budget Control Act spending caps.

10. See Megan Eckstein, 'Large Surface Combatant Program Delayed Amid Pivot Towards Unmanned, Other Emerging Tech' posted to the *USNI News* website on 13 March 2019 at: https://news.usni.org/2019/03/13/large-surface-combatant-program-delayed-amid-pivot-towards-unmanned-other-emerging-tech

11. See Ronald O' Rourke, *Navy DDG-51 and DDG-1000 Destroyer Programs: Background and Issues for Congress RL32109* (Washington DC: Congressional Research Service, 2019), p.4.

12. General Dynamics Electric Boat press release entitled 'Statement of Electric Boat President Jeff Geiger on US Navy Award of Columbia-class Ballistic Missile Submarine Contract' released on 20 May 2019.

13. See David B. Larter, 'Late is the new normal for *Virginia*-class attack boats' posted to the *Defense News* website on 20 March 2019 at: https://www.defensenews.com/naval/2019/03/20/late-is-the-new-normal-for-virginia-class-attack-boats/

14. *Report to Congress on the Long-Range Plan for Maintenance and Modernization of Naval Vessels for Fiscal Year 2020* (Washington DC: Naval Sea Systems Command, 2019).

15. Some of the maintenance issues facing the fleet were provided by Michael Fabey in 'US Navy faces headwinds as it struggles to maintain its fleet', *Jane's Defence Weekly* – 2 January 2019 (Coulsdon: IHS Jane's, 2019), p.13. The article reports that the equivalent of seventeen ships and submarines were not available during 2018 because they were waiting to get into or out of maintenance.

16. A detailed review of some of the factors impacting, particularly, the destroyer *Fitzgerald*'s (DDG-62's) collision with the MV *Crystal* on 17 June 2017 is provided by Michael Fabey in 'Heavy Seas: US Navy surface fleet safety – Briefing' published in *Jane's Defence Weekly* – 10 April 2019 (Coulsdon: IHS Jane's, 2019), pp.26–31. For some of the impact on deployments see Geoff Ziezulewicz, 'PACFLEET commander says this happens when a ship isn't ready to deploy' posted to the *Navy Times* website on 26 February 2019 at: https://www.navytimes.com/news/your-navy/2019/02/26/pacfleet-commander-says-this-happens-when-a-ship-isnt-ready-to-deploy/. Court martial proceeding against *Fitzgerald's* commander and a more junior officer were dropped in April 2019 in a decision possibly driven by a number of prejudicial statements made by navy leadership on the tragic events. The pair received formal letters of censure that carry no legal weight but which are likely to end their careers with no right of appeal.

17. See Ronald O'Rourke, *Coast Guard Cutter Procurement: Background and Issues for Congress – R42567* (Washington DC: Congressional Research Service, 2019), pp.8–9.

18. See Victor Barriera's 'Brazil decommissions its only aircraft carrier - *Jane's Defence Weekly* – 5 December 2018 (Couldson: IHS Jane's, 2018), p.11.

19. This section has benefitted from the ongoing coverage of the Brazilian Navy in the Portuguese language Poder Naval website at: naval.com.br/blog/

20. A comprehensive overview of the Venezuelan Navy's current operational status was provided by Andrea Guidulgi on the Spanish-language *infodefensa.com* website between 29 March and 4 April 2019. Along with official navy websites, infodefensa.com and its competitor defensa.com remain invaluable sources of information on naval developments in South America.

2.2 REGIONAL REVIEW

ASIA AND THE PACIFIC

Author:
Conrad Waters

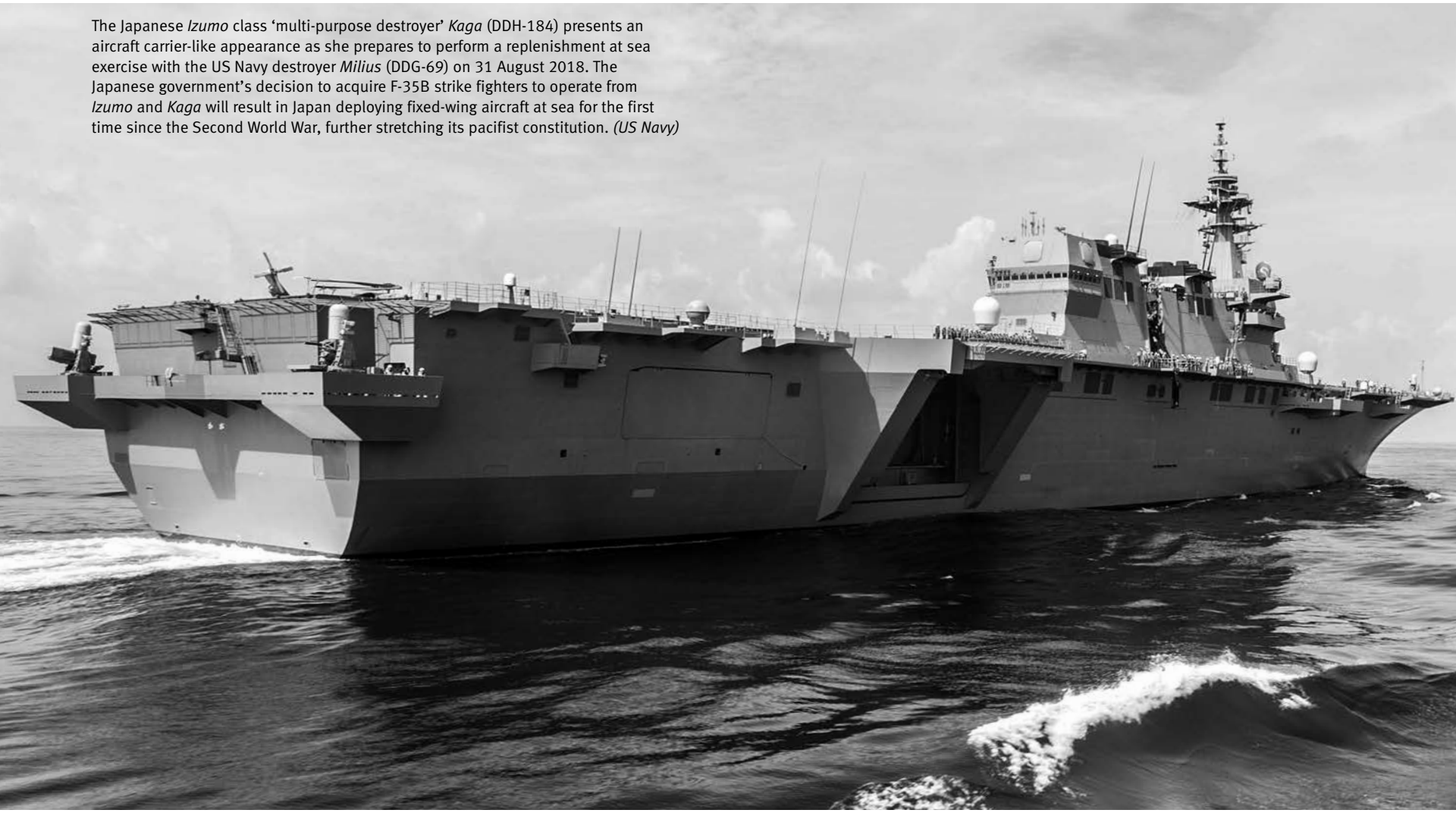
On 18 December 2018 the Japanese National Security Council and Cabinet approved the new *National Defense Program Guidelines for FY2019 and beyond*. The guidelines essentially set out a view of the main security challenges facing Japan over the next decade and the measures that are proposed to meet them. It is clear that it is the continued rise of China's military power and its appetite for expansionism that gives Japan most cause for concern. This is evidenced, for example, by the statement that 'China engages in unilateral, coercive attempts to alter the status quo based on its own assertions that are incompatible with existing international order'. Whilst the alliance with the United States continues to be the cornerstone of security policy, the guidelines commit to strengthen Japan's own defensive capabilities. In common with many other recent defence white papers there is a recognition that this capacity needs to be developed in new domains – cyber, space and across the electromagnetic spectrum – as well as in the traditional air, land and sea environments.[1]

Despite the broad spectrum of security enhancements that Japan envisages, one specific announcement received the vast majority of press attention. It was confirmed that Japan will acquire the F-35B short take-off and vertical landing (STOVL) variant of the Lightning II strike fighter and modify the two *Izumo* (DDH-183) class helicopter-carrying destroyers to deploy them at sea. The decision was explained on the basis of a need to expand military aviation capabilities over the waters of the Pacific Ocean, where the number of air bases is limited. Current plans state that forty-two of the jets will eventually be acquired, eighteen during the life of the current *Medium Term Defense Program (FY2019-FY2023)*.[2]

The decision has significant implications for Japanese – and wider regional – defence policy for two main reasons. First, it marks the first time that Japan will deploy fixed-wing aircraft at sea since the end of the Second World War. This arguably marks a further step in the erosion of the pacifist Article 9 of Japan's constitution, which outlaws the country's recourse to war as a means of settling disputes and prohibits the maintenance of armed forces with military potential. The prohibition has long been treated as preventing the acquisition of offensive military systems, which the deployment of aircraft carriers arguably further weakens. Japan has re-designated the *Izumo* class as 'multi-purpose destroyers' to try to reduce the inevitable criticism. Perhaps unconvincingly, Japanese premier Shinzo Abe has justified this obfuscation by arguing that the ships were not designed specifically for the sole operation of aircraft so fall outside the definition of an aircraft carrier.

The other important aspect of the revised policy is the relative ease to which the JMSDF will be able to adapt to fast jet deployment at sea. Acquiring proficiency in such operations is a potentially lengthy and costly business. It will take considerable effort to achieve, even assuming significant support is provided by Japan's American ally. Moreover, whilst current plans envisage a modest increase in future defence spending, it is not entirely certain there will be enough money to sustain this expensive new capability alongside other requirements. Consequently, there has to be something of a question whether Japan's return to carrier operations is more of a political gimmick than a meaningful addition to the country's defence potential.

Although China's rise attracts most attention in Japan's policy guidelines, North Korea's nuclear and ballistic weapons programmes also remain a major concern. The swift breakdown of the second summit between the United States and North Korea, held in Hanoi in February 2019, has resulted in a return to tensions on the peninsula. As always, the future direction of travel is unpredictable. The situation is further complicated by doubts over the extent of the Trump administration's commitment to regional security and friction between Japan and South Korea that are largely a legacy of Japan's previous occupation of the Korean peninsula. The latter has been reflected in a number of recent diplomatic incidents. These include allegations that a Japanese maritime patrol aircraft was targeted by a Republic of Korea Navy destroyer's radar in December 2018 and South Korean complaints of Japanese aircraft 'buzzing' their ships in international waters. Ironically, the North's return to more aggressive behaviour may have served to ease the dispute, with both parties determining it better to focus on the dangers posed by a common and more threatening enemy.[3]



The Japanese *Izumo* class 'multi-purpose destroyer' *Kaga* (DDH-184) presents an aircraft carrier-like appearance as she prepares to perform a replenishment at sea exercise with the US Navy destroyer *Milius* (DDG-69) on 31 August 2018. The Japanese government's decision to acquire F-35B strike fighters to operate from *Izumo* and *Kaga* will result in Japan deploying fixed-wing aircraft at sea for the first time since the Second World War, further stretching its pacifist constitution. *(US Navy)*

Table 2.2.1: FLEET STRENGTHS IN ASIA AND THE PACIFIC – LARGER NAVIES (MID 2019)

COUNTRY	AUSTRALIA	CHINA	INDONESIA	JAPAN	S KOREA	SINGAPORE	TAIWAN	THAILAND
Aircraft Carrier (CV)	–	2	–	–	–	–	–	–
Support/Helicopter Carrier (CVS/CVH)	–	–	–	4	–	–	–	1
Strategic Missile Submarine (SSBN)	–	6	–	–	–	–	–	–
Attack Submarine (SSN)	–	9	–	–	–	–	–	–
Patrol Submarine (SSK/SS)	6	50	4	19	17	4	4	–
Fleet Escort (DDG/FFG)	11	70	8	38	25	6	26	8
Patrol Escort/Corvette (FFG/FSG/FS)	–	50	24	6	13	11	1	11
Missile Armed Attack Craft (PGG/PTG)	–	75	21	6	18	–	c.30	6
Mine Countermeasures Vessel (MCMV)	4	25	11	23	9	4	10	6
Major Amphibious Units (LHD/LPD/LSD)	3	6	6	3	1	4	1	1

Notes: Chinese numbers approximate; Some additional Indonesian patrol gunboats are able to ship missiles; South Korean fleet escorts include thirteen deployed in littoral warfare roles; Taiwan's submarines are reported to have limited operational availability.

MAJOR REGIONAL POWERS – AUSTRALIA

The last year has seen the Royal Australian Navy start to put its most significant acquisition programmes into action. By far the largest of these is the construction of twelve new submarines to Naval Group's 'Shortfin Barracuda' design at an estimated cost of AU$50bn (c. US$35bn) under the SEA 1000 programme. Press reports suggest that there were some difficulties finalising contractual arrangements with the French company. However, an over-arching 'strategic partnering agreement' (SPA) signed on 11 February 2019 brought these negotiations to a successful conclusion. Preparatory work on the programme had been underway since late 2016 under a preliminary design and mobilisation contract. Following signature of the SPA, the project has now moved into more detailed design through an AU$605m (c. US$425m) submarine design contract inked on 5 March.

The ship's company of the Royal Australian Navy's replenishment oiler *Success* gather on her flight deck to celebrate the ship's 33rd birthday during the Indo-Pacific Endeavour 2019 deployment. The construction of replacement ships is now well advanced in Spain and *Success* was decommissioned on 29 June 2019. *(Royal Australian Navy)*

Work has also started on constructing the new facility in Osborne, South Australia that will build the submarines. This will be operated by government-owned shipbuilder ASC, which plans to commence assembly in the early 2020s. However, even if everything proceeds according to plan the first submarine – to be named *Attack* – will not be completed before 2032 and only become operational in 2035. There are already plans to extend the lives of many of the six existing *Collins* class boats to ensure a credible underwater flotilla is maintained. Even so, their age – *Collins* will celebrate its fortieth birthday in 2036 – suggest that there is little scope for delay in the replacement programme.

Progress following the June 2018 selection of BAE Systems' Type 26 Global Combat Ship design to meet requirements of the AU$35bn (c. US$25bn) SEA 5000 frigate programme has been somewhat more rapid. This possibly reflects the greater maturity of the Type 26 design. Signature of an advanced work arrangement in October 2018 was followed by conclusion of an overall framework agreement for the design and build of the nine ships. They are scheduled to be delivered from 2027 onwards.[4] The new class will be known as the *Hunter* class after Vice Admiral John Hunter, the second governor of New South Wales. Construction will be carried out at another new facility in Osborne by ASC Shipbuilding, which has been split from its ASC parent to become a subsidiary of BAE for the duration of the contract. The Australian government's aim is that the arrangement will provide the technology, intellectual property and workforce required to sustain an indigenous construction capability when BAE Systems hands back the yard when the ships have been completed.

The other major domestic construction contract is for twelve new offshore patrol vessels being built

Table 2.2.2: ROYAL AUSTRALIAN NAVY: PRINCIPAL UNITS AS AT MID 2019

TYPE	CLASS	NUMBER	TONNAGE	DIMENSIONS	PROPULSION	CREW	DATE
Principal Surface Escorts							
Frigate – FFG	**HOBART** (F-100)	2	6,300 tons	147m x 19m x 5m	CODOG, 28 knots	200	2017
Frigate – FFG	**ANZAC**	8	3,600 tons	118m x 15m x 4m	CODOG, 28 knots	175	1996
Frigate – FFG	**ADELAIDE** (FFG-7)	1	4,200 tons	138m x 14m x 5m	COGAG, 30 knots	210	1980
Submarines							
Submarine – SSK	**COLLINS**	6	3,400 tons	78m x 8m x 7m	Diesel-electric, 20 knots	45	1996
Major Amphibious Units							
Amph Assault Ship – LHD	**CANBERRA** (JUAN CARLOS I)	2	27,100 tons	231m x 32m x 7m	IEP, 21 knots	290	2014
Landing Ship Dock – LSD	**CHOULES** (LARGS BAY)	1	16,200 tons	176m x 26m x 6m	Diesel-electric, 18 knots	160	2006

to Lürssen's OPV design under Project SEA 1180 Phase 1. Construction work on the programme commenced at ASC on 15 November 2018, when it was announced that the ships would be known as the *Arafura* class. A formal keel-laying ceremony followed on 10 May 2019. The first pair of vessels will be constructed in Osborne to assist the transition from *Hobart* to *Hunter* class production. Work on the ten later ships will be carried out at Henderson, Western Australia under the auspice of the Australian Maritime Shipbuilding and Export Group joint venture between Lürssen and Civmec. Henderson has also been nominated as the location for construction of a new hydrographic ship and two mine warfare support vessels. The latter are intended to operate autonomous mine clearance vehicles in eventual replacement of the existing *Huon* class.

Away from Australia, good progress is being made by Navantia at Ferrol in Spain building the two new *Supply* class replenishment oilers that will replace the Royal Australian Navy's existing replenishment capabilities. *Supply* herself was launched on 24 November 2018, with the keel of her sister *Stalwart* being laid the following day. A start has already been made on withdrawing the navy's existing auxiliary oilers. The veteran *Success*, completed at the former Cockatoo Island Dockyard in 1986 to a French *Durance* class design, was decommissioned on 29 June 2019 after 33 years' service.

Table 2.2.2 provides an overview of current Royal Australian Navy strength as at mid-2019. The second Aegis-equipped *Hobart* class frigate, *Brisbane*, was delivered in July 2018 prior to formal commissioning on 27 October. Her sister *Sydney* will follow before the end of 2019. The new ships have already undertaken successful trials of their cooperative engagement capability (CEC), becoming the first ships outside the US Navy to demonstrate this functionality.

The *Hobart* class's arrival is allowing withdrawal of the final *Adelaide* (FFG-7) class frigates. *Newcastle* decommissioned on 30 June 2019 after a deployment to the Indian Ocean as part of the 'Indo-Pacific Endeavour 2019' task group.[5] Her sister *Melbourne* is scheduled to follow her into retirement on 26 October after returning to Australia from a final Asia-Pacific cruise in June. Also finally leaving the fleet are the *Huon* class minehunters *Hawkesbury* and *Norman*. Laid up in reserve since 2011, the two ships were officially decommissioned in the autumn of 2018 and earmarked for sale as the fleet looks to autonomous systems for its future mine countermeasures capabilities.

The Royal Australian Navy *Adelaide* class frigate *Newcastle* departs Newcastle Harbour for the last time before decommissioning at Sydney on 30 June 2019. Her sister *Melbourne* – the last operational member of the class – will also leave the fleet before the year's end. *(Royal Australian Navy)*

MAJOR REGIONAL POWERS – CHINA

On 23 April 2019 the People's Liberation Army Navy (PLAN) held a fleet review off Qingdao in northern China to celebrate the seventieth anniversary of its establishment. The importance of the event was signified by the participation of China's premier, Xi Jinping, who embarked in the Type 052 destroyer *Xining* to observe the proceedings. In spite of overcast conditions, the review provided the navy with an opportunity to showcase some of its latest acquisitions. Prominent amongst these were the new Type 055 destroyer *Nanchang* and an improved variant of the Type 094 class strategic submarine. Although a number of navies – including those of Australia, India, Japan, South Korea and Russia – sent their warships to attend the event, the US Navy was conspicuous by its absence.

An editorial published in the *Global Times*, part of the Chinese Communist Party's *People's Daily* newspaper group, provided an official perspective on events.[6] Entitled 'A Powerful PLA Navy provides a solid foundation for China's peaceful development', it stressed the defensive nature of the PLAN's build-up. Declaring that '. . . the strong Chinese Navy will never follow the maritime imperial actions that some major navies have done before' it warned that 'One of the purposes of China's construction of a strong navy is to restrain arrogant, external forces from crossing China's doorstep'. The theme was subsequently taken up by China's defence minister General Wei Fenghe at the Shangri-La security summit in Singapore on 2 June. He denounced countries from outside the region who have come to the South China Sea to flex their muscles in the name of freedom of navigation, whilst stating that China could not rule out force to achieve the eventual reunification of Taiwan.[7]

These various statements reveal something of the ongoing conflict between a Chinese narrative portraying its actions as those of a peace-loving country striving to rectify past humiliations and the fears of others – both in the region and elsewhere – that China will use its new naval power to impose its will on those nations taking a dissenting world view. The likely impact on China's economic interests

would seemingly serve as a powerful deterrent to the use of military action unless by accident or in extremis. At the same time it is apparent that China's leadership have a very similar perspective to the American Trump administration in using its armed forces as part of a 'toolkit' to gain competitive advantage in a period of great power rivalry. As noted in the latest US Department of Defense report to Congress on Chinese military and security developments, 'China increasingly seeks to leverage its growing economic, diplomatic, and military clout to establish regional pre-eminence and expand its international influence.'[8] The PLAN's combination of well-developed A2/AD forces and expanding expeditionary assets is an increasingly important element of this strategy.

Table 2.2.3 demonstrates the continued quantitative and, particularly, qualitative expansion of PLAN capacity, as supplemented by the more detailed analysis under specific category headings below.

Aircraft Carriers and Amphibious Ships: China's first aircraft carrier *Liaoning* has remained active assisting the PLAN to develop carrier group operating practice, venturing into the Pacific as far as the vicinity of Guam in June 2019. The broadly similar but entirely domestically-built Type 001A variant has continued to undertake a series of sea trials. These have recently extended to practice operations with fast jets. Her commissioning was reported to be imminent as of mid-2019. The last year has seen photographic evidence emerge of a third, Type 002 aircraft carrier in the early stages of construction at the Jiangnan shipyard in Shanghai. Most reports suggest that – in contrast to the first two, ski-jump-equipped ships – she will be of conventional catapult assisted but arrested recovery (CATOBAR) configuration, possibly incorporating electromagnetic launch systems. She is unlikely to be operational before the mid-2020s.[9]

Construction of larger amphibious vessels continues to be dominated by the Type 071 'Yuzhao' amphibious transport docks, which have all been assembled at the Hudong Zhonghua yard in Shanghai. The last twelve months have seen the delivery of the fifth and sixth vessels of the series, named *Longhu Shan* and *Wuzhi Shan*. Two more are in an advanced stage of construction, with the

Table 2.2.3: PEOPLE'S LIBERATION ARMY NAVY: PRINCIPAL UNITS AS AT MID 2019

TYPE	CLASS	NUMBER	TONNAGE	DIMENSIONS	PROPULSION	CREW	DATE
Aircraft Carriers							
Aircraft Carrier – CV	Type 001A (Modified Kuznetsov)	1	65,000 tons	315m x 35/75m x 10m	Steam, 32 knots	Unknown	2019
Aircraft Carrier – CV	Type 001 **LIAONING** (Kuznetsov)	1	60,000 tons	306m x 35/73m x 10m	Steam, 32 knots	Unknown	2012
Principal Surface Escorts							
Destroyer – DDG	Type 055 **NANCHANG** ('Renai')	1	c.12,000 tons	180m x 20m x 7m	COGAG, 30 knots	c.300	2019
Destroyer – DDG	Type 052D **KUNMING** ('Luyang III')	11	7,500 tons	156m x 17m x 6m	CODOG, 28 knots	280	2014
Destroyer – DDG	Type 051C **SHENYANG** ('Luzhou')	2	7,100 tons	155m x 17m x 6m	Steam, 29 knots	Unknown	2006
Destroyer – DDG	Type 052C **LANZHOU** ('Luyang II')	6	7,000 tons	154m x 17m x 6m	CODOG, 28 knots	280	2004
Destroyer – DDG	Type 052B **GUANGZHOU** ('Luyang I')	2	6,500 tons	154m x 17m x 6m	CODOG, 29 knots	280	2004
Destroyer – DDG	Project 956E/EM **HANGZHOU** (Sovremenny)	4	8,000 tons	156m x 17m x 6m	Steam, 32 knots	300	1999
Destroyer – DDG	Type 051B **SHENZHEN** ('Luhai')	1	6,000 tons	154m x 16m x 6m	Steam, 31 knots	250	1998
Destroyer – DDG	Type 052 **HARBIN** ('Luhu')	2	4,800 tons	143m x 15m x 5m	CODOG, 31 knots	260	1994
Two obsolescent destroyers of the Type 051 **JINAN** ('Luda') class remain in service.							
Frigate – FFG	Type 054A **XUZHOU** ('Jiangkai II')	30	4,100 tons	132m x 15m x 5m	CODAD, 28 knots	190	2008
Frigate – FFG	Type 054 **MA'ANSHAN** ('Jiangkai I')	2	4,000 tons	132m x 15m x 5m	CODAD, 28 knots	190	2005
Frigate – FFG	Type 053 H3 **LIANYUNGANG** ('Jiangwei II')	10	2,500 tons	112m x 12m x 5m	CODAD, 27 knots	170	1992
Frigate – FSG	Type 056/056A **BENGBU** ('Jiangdao')	45+	1,500 tons	89m x 12m x 4m	CODAD, 28 knots	60	2013
Plus c.5–10 additional obsolescent frigates of Type 053 H1/H1G/H2 **TAIZHOU** ('Jianghu II-V') classes							
Submarines							
Submarine – SSBN	Type 094 ('Jin')	c.4+	9,000 tons	133m x 11m x 8m	Nuclear, 20+ knots	Unknown	2008
Submarine – SSBN	Type 092 ('Xia')	1	6,500 tons	120m x 10m x 8m	Nuclear, 22 knots	140	1987
Submarine – SSN	Type 093/093A ('Shang')	c.6	6,000 tons	107m x 11m x 8m	Nuclear, 30 knots	100	2006
Submarine – SSN	Type 091 ('Han')	3	5,500 tons	106m x 10m x 7m	Nuclear, 25 knots	75	1974
Submarine – SSK	Type 039A/039B (Type 041 'Yuan')	12+	2,500 tons	75m x 8m x 5m	AIP, 20+ knots	Unknown	2006
Submarine – SSK	Type 039/039G ('Song')	13	2,300 tons	75m x 8m x 5m	Diesel-electric, 22 knots	60	1999
Submarine – SSK	Project 877 EKM/636 ('Kilo')	12	3,000 tons	73m x 10m x 7m	Diesel-electric, 20 knots	55	1995
Plus c.15 obsolescent patrol submarines of the Type 035 ('Ming' class). A Type 032 'Qing' trials submarine has also been commissioned for strategic missile trials.							
Major Amphibious Units							
Landing Platform Dock	Type 071 **KULUN SHAN** ('Yuzhao')	6	18,000 tons	210m x 27m x 7m	CODAD, 20 knots	Unknown	2007

eighth launched on 6 June 2019. In spite of ongoing speculation, there is still no conclusive evidence that work on the much-rumoured Type 075 amphibious assault ship is currently underway.

Surface Combatants: There are some indications that China is making attempts to conceal the current extent of its surface shipbuilding programmes, with information on launches and commissionings being less readily available than hitherto.[10] In spite of this, the availability of satellite and other open source information makes it possible to gain a broad understanding of the overall picture.

The top end of PLAN surface ship construction is currently represented by the Type 055 'Renai' class destroyers. The lead ship *Nanchang* is the only one to have been delivered to date. Construction of the class is split between the Jiangnan and Dalian shipyards that are responsible for the smaller Type 052D destroyers. It is believed that a further five of a total class that could comprise eight or more units are currently under construction, of which three have been launched to date.

Construction of the earlier Type 052D 'Luyang III' design has continued alongside the new Type 055s. Eleven had entered service as of mid-2019. A further nine are fitting out following the simultaneous float-out of the nineteenth and twentieth units at Dalian Shipbuilding Industry Corporation's yard on 10 May 2019. At least four more are under assembly. The most recent ships are reportedly 4m longer than their sisters to provide a larger flight deck for the new Z-20 helicopter. There may also be some sensor and other detailed changes to the later ships.

Production of the popular Type 054A 'Jiangkai II' frigates for PLAN service appears to have ended with the commissioning of the thirtieth member of the class, *Zaozhuang*, on 22 February 2019. She was completed by the Huangpu Shipyard at Guangzhou, which has shared construction with Shanghai's Hudong Zhonghua. There is still no sign of a start of work on the much-rumoured Type 054B/Type 57 follow-on class but four Type 054As still need to be completed to fill an export contract with Pakistan.

There has been no let-up in construction of the diminutive Type 056/Type 056A 'Jiangdao' series of corvettes, which continue to be assembled by Hudong Zhonghua, Huangpu, the Liaonan yard in Dalian and the Wuchang shipyard in Wuhan. As of mid-2019, around forty-five of the class were in service with another fifteen launched.

The PLAN's first aircraft carrier, *Liaoning*, continues to be busy helping the navy develop carrier operating tactics and was present at the April 2019 fleet review off Qingdao. This earlier photograph shows her operating with the Type 052C destroyers *Zhengzhou* and *Jinan*, now replaced in production with the more recent Type 052Ds. *(China Military)*

The arrival of so many new ships is allowing the withdrawal of older, obsolescent units. Notably, four of the remaining Type 051 'Luda' were decommissioned at a ceremony at Dalian in May 2019. This leaves only two of the class – *Zhanjiang* and *Zhuhai* – in service and they are also expected to be gone soon. Inroads are also being made into the older Type 053 frigates, which are being progressively downgraded to coast guard duties, transferred to foreign navies or scrapped.

Support Vessels: A noteworthy feature of recent PLAN construction has been the ongoing completion of a series of replenishment vessels capable of sustaining 'blue water' oceanic operations at distance from Chinese waters. Initial construction was focused on the Type 903/903A 'Fuchi' class replenishment oilers. Eight of these were completed in two batches between 2004 and 2016. In May 2018, a ninth vessel was launched from the Huangpu Shipyard at Guangzhou, suggesting more capacity may be required. These vessels are typically used to support surface escort flotillas on international deployments, most notably during the regular anti-piracy missions to the Indian Ocean.

A more recent development has been the arrival of the Type 901 fast combat support ships, which are also being built at Guangzhou. Apparently modelled on the US Navy's *Supply* (T-AOE-6) class, these are much larger, c. 45,000–50,000-ton vessels that utilise gas turbine propulsion to achieve speeds in excess of 25 knots. They are purposely designed to support fast-moving carrier task group operations through the provision of liquid and dry stores. Media reports suggest that they have five replenishment at sea (RAS) stations for liquid transfer and two solid supply rigs as well as a stern reel. Helicopter-operating facilities are also provided to allow vertical replenishment. Two members of the class are currently in service following the delivery of *Chagan Hu* in February 2019. A further pair are believed to be in the early stages of construction.

Submarines: Tracking the development of the PLAN's submarine force remains fraught with difficulty given negligible official transparency and a lack of reliable open source information. However, analysis of satellite imagery has pointed to further development of the PLAN's strategic submarine force over the last year with the emergence of what appears to be two additional Type 094 'Jin' class boats under construction at the Bohai Shipbuilding yard in Huludao in November 2018.[11] These would join at least four older Type 094s that are currently in service. It is not apparent to what extent these latest submarines differ from earlier members of the class. However, a total of six corresponds with the conclusion in the *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2019*. The April 2019 fleet review

Table 2.2.4: JAPAN MARITIME SELF-DEFENCE FORCE: PRINCIPAL UNITS AS AT MID 2019

TYPE	CLASS	NUMBER	TONNAGE	DIMENSIONS	PROPULSION	CREW	DATE
Support and Helicopter Carriers							
Helicopter Carrier – DDH	**IZUMO** (DDH-183)	2	27,000 tons	248m x 38m x 7m	COGAG, 30 knots	470	2015
Helicopter Carrier – DDH	**HYUGA** (DDH-181)	2	19,000 tons	197m x 33m x 7m	COGAG, 30 knots	340	2009
Principal Surface Escorts							
Destroyer – DDG	**ATAGO** (DDG-177)	2	10,000 tons	165m x 21m x 6m	COGAG, 30 knots	300	2007
Destroyer – DDG	**KONGOU** (DDG-173)	4	9,500 tons	161m x 21m x 6m	COGAG, 30 knots	300	1993
Destroyer – DDG	**HATAKAZE** (DDG-171)	2	6,300 tons	150m x 16m x 5m	COGAG, 30 knots	260	1986
Destroyer – DDG	**ASAHI** (DD-119)	2	6,800 tons	151m x 18m x 5m	COGLAG, 30 knots	230	2017
Destroyer – DD	**AKIZUKI** (DD-115)	4	6,800 tons	151m x 18m x 5m	COGAG, 30 Knots	200	2012
Destroyer – DDG	**TAKANAMI** (DD-110)	5	6,300 tons	151m x 17m x 5m	COGAG, 30 knots	175	2003
Destroyer – DDG	**MURASAME** (DD-101)	9	6,200 tons	151m x 17m x 5m	COGAG, 30 knots	165	1996
Destroyer – DDG	**ASAGIRI** (DD-151)	8	4,900 tons	137m x 15m x 5m	COGAG, 30 knots	220	1988
Destroyer – DDG	**HATSUYUKI** (DD-122)	2 (3)	3,800 tons	130m x 14m x 4m	COGOG, 30 knots	200	1982
Frigate – FFG	**ABUKUMA** (DE-229)	6	2,500 tons	109m x 13m x 4m	CODOG, 27 knots	120	1989
Submarines							
Submarine – SSK	**SORYU** (SS-501)	10	4,200 tons	84m x 9m x 8m	AIP, 20 knots+	65	2009
Submarine – SSK	**OYASHIO** (SS-590)	9 (2)	4,000 tons	82m x 9m x 8m	Diesel-electric, 20 knots+	70	1998
Major Amphibious Units							
Landing Platform Dock – LPD	**OSUMI** (LST-4001)	3	14,000 tons	178m x 26m x 6m	Diesel, 22 knots	135	1998

Note: Figures in brackets refer to trials or training ships.

The lead *Asahi* class destroyer pictured in the course of pre-delivery trials in December 2017. Production has now switched to the smaller and cheaper 30FMM class as the JMSDF attempts to expand fleet numbers. *(JMSDF)*

off Qingdao included a Type 094A submarine with a slightly different configuration to those seen in previous images but it is not entirely clear whether this is one of the earlier four or one of the new pair. Meanwhile, work is continuing on the longer-range JL-3 submarine-launched ballistic missile, which will reportedly equip a new generation of Type 096 submarines. There have been reports of test launches in November 2018 and June 2019, probably using the Type 032 diesel-electric 'Qing' class submarine that was constructed for this purpose.

Little fresh information has arisen with respect to the PLAN's c. 50-strong force of conventionally-powered submarines analysed in last year's *Seaforth World Naval Review*.

MAJOR REGIONAL POWERS – JAPAN

The future trajectory of the Japan Maritime Self Defence Force (JMSDF) was confirmed with the publication of the *Medium Term Defense Program (FY2019-FY2023)* in December 2018. Total defence

spending in the period will amount to the equivalent of c. US$240bn, around eleven percent higher than during the previous five-year period. In addition to the acquisition of F-35B jets for the *Izumo* class destroyers, the medium-term programme provides for a material boost to naval construction. A total of twenty-three warships and submarines with a displacement of c. 66,000 tons will be ordered. This compares with fifteen ships displacing 52,000 tons under the FY2014–FY2018 programme.

The surface fleet was set a target strength of fifty-four destroyers – including four 'helicopter carrying destroyers' and eight Aegis-equipped air-defence ships – in the previous FY2014 *Defense Program Guidelines*. This target is maintained in the current plan. At present, as shown in Table 2.2.4, there are only forty-eight surface escorts – including the four *Izumo* and *Hyuga* class 'carriers' – in the fleet and some of these are quite elderly. There is therefore some way to go to meeting the target. The solution appears to be based on series production of the new smaller and cheaper 30DD type destroyers, which are now officially referred to as multi-purpose frigates or FFMs. Two of an initial batch of eight were authorised in the FY2018 defence budget and production will continue at a similar rate – probably with a switch to an improved variant from FY2022 – during the life of the current five-year defence programme. Deliveries will take place from 2021 onwards. In the interim, the JMSDF commissioned the second and final *Asahi* class destroyer, *Shiranui*, in February 2019 and will receive the two new *Maya* class Aegis-equipped air-defence destroyers in 2020 and 2021. The first of these, which will be 5m longer and around 500 tons heavier than the previous Aegis-equipped *Atago* class, was launched by Japan Marine United at Yokohama on 30 July 2018.

Given no material increase in JMSDF personnel is envisaged, crewing the larger fleet will clearly be a challenge. Part of the answer is the lower complement planned for the FFMs – a total of 100 compared with over 200 for a more traditional destroyer – and the deployment of unmanned vehicles from these ships to perform duties historically performed by manned minehunters. Although some new oceanic minehunters will still be procured, this suggests the total number of mine countermeasures vessels in the fleet will continue to decline. The FY2019 *Defense Program Guidelines* do, however, commit to the acquisition of a new class of patrol vessel that will improve surveillance capabilities in home waters. Twelve of these will eventually be acquired, with four being ordered under the FY2019–FY2023 programme. Media reports suggest these will be relatively large and well-armed vessels with more than a purely constabulary role.

The FY2019 *Defense Program Guidelines* mandate an operational submarine flotilla of twenty-two boats. Again, this is unchanged from the previous guidelines but it represents an increase of three from the current number. It also seems that an existing submarine will be converted to a specialist trials boat to add to the two existing second-line units that are designated as training assets. The increase in the front-line flotilla will be achieved through life extensions of *Oyashio* class boats whilst continuing to order new submarines at the rate of one p.a. This is eminently feasible given the JMSDF has historically retired submarines after around 20 years of service but obtaining the additional crews may be more difficult. Meanwhile, the tenth *Soryu* class boat, *Shoryu*, commissioned in March 2019 and the eleventh, *Oryu*, was launched on 4 October 2018. The latter is the first to be equipped with lithium-ion batteries in place of air-independent propulsion (AIP).

MAJOR REGIONAL POWERS – SOUTH KOREA

The Republic of Korea's military continues to be faced with the dilemma of how to balance the country's desire to expand its international influence with the need to prepare for aggression by its volatile and potentially nuclear-armed northern neighbour. The extent of the Trump administration's commitment to defending the Republic, exacerbated by a spat over how much South Korea should contribute to the cost of US forces stationed in the peninsula, is a further concern. The current Moon Jae-in administration announced a new 'Defense Reform 2.0' initiative in July 2018 in the hope of squaring the circle. Combining personnel reductions with additional investment in equipment and new technologies, the strategy includes a substantial boost to already buoyant defence spending. A healthy 8.2 percent increase in the defence budget to KRW 46.7 trillion (c. US$42bn) has been agreed for FY2019. The average annual rate of increase projected for the FY2019–FY2023 period is 7.5 percent, approaching double the 4.9 percent annual increase achieved between FY2009 and FY2018.[12] The resultant KRW 61.8 trillion (c.US$55bn) spending would likely exceed that of

The Republic of Korea Type 214 submarine *Hong Beom-do* was the seventh member of nine *Son Won-il* class boats built domestically in South Korea. Production is now drawing to a close as the navy transitions to the new KSS-III type. This picture was taken in October 2018 in the course of an International Fleet Review held off the island of Jeju. *(Arjun Sarup)*

Table 2.2.5: REPUBLIC OF KOREA NAVY: PRINCIPAL UNITS AS AT MID 2019

TYPE	CLASS	NUMBER	TONNAGE	DIMENSIONS	PROPULSION	CREW	DATE
Principal Surface Escorts							
Destroyer – DDG	KDX-III **SEJONGDAEWANG-HAM**	3	10,000 tons	166m x 21m x 6m	COGAG, 30 knots	300	2008
Destroyer – DDG	KDX-II **CHUNGMUGONG YI SUN-SHIN**	6	5,500 tons	150m x 17m x 5m	CODOG, 30 knots	200	2003
Destroyer – DDG	KDX-I **GWANGGAETO-DAEWANG**	3	3,900 tons	135m x 14m x 4m	CODOG, 30 knots	170	1998
Frigate – FFG	FFX-2 **DAEGU**	1	3,600 tons	122m x 14m x 4m	CODLOG	140	2017
Frigate – FFG	FFX **INCHEON**	6	3,000 tons	114m x 14m x 4m	CODOG, 30 knots	140	2013
Frigate – FFG	**ULSAN**	6	2,300 tons	102m x 12m x 4m	CODOG, 35 knots	150	1981
Corvette – FSG	**POHANG**	13	1,200 tons	88m x 10m x 3m	CODOG, 32 knots	95	1984
Submarines							
Submarine – SSK	KSS-2 **SON WON-IL** (Type 214)	8	1,800 tons	65m x 6m x 6m	AIP, 20+ knots	30	2007
Submarine – SSK	KSS-1 **CHANG BOGO** (Type 209)	9	1,300 tons	56m x 6m x 6m	Diesel-electric, 22 knots	35	1993
Major Amphibious Units							
Amph Assault Ship – LHD	LPX **DOKDO**	1	18,900 tons	200m x 32m x 7m	Diesel, 22 knots	425	2007

Japan. A major question mark is whether South Korea's slowing economy will be able to support this military largesse. The near bankruptcy of Daewoo Shipbuilding & Marine Engineering (DSME) – which looks set to be forced into a merger with its rival Hyundai Heavy Industries (HHI) – is indicative of the challenges facing the country.

There is certainly no shortage of naval projects on which to spend the additional money. Prominent amongst these is the build-up of the submarine force, which has gained further momentum in the last year. September 2018 saw the launch of the lead KSS-III AIP-equipped diesel-electric submarine by DSME at a ceremony attended by Premier Moon Jae-in. *Dosan Ahn Chang-Ho* subsequently commenced trials in June 2019 and is expected to be delivered before the end of 2020. The first submarine of indigenous South Korean design, she is believed to displace in the region of 3,800 tons in submerged condition. Armament includes six VLS tubes as well as eight standard torpedo tubes. Orders for an additional pair have been split between DSME and HII, whilst the preliminary design for a second batch of three was agreed towards the end of 2018. In contrast to the first batch, these are expected to be equipped with lithium-ion batteries. December 2018 also saw an order awarded for a new auxiliary submarine rescue ship designated ASR-II that is specifically designed to support the new KSS-III flotilla. Meanwhile, HII is close to delivering the last submarine – *Shin Sol-deok* – built under the previous KSS-II programme. This has seen the local construction of nine AIP-equipped boats to ThyssenKrupp Marine System's Type 214 design.

The launch ceremony for *Marado*, the Republic of Korea's second amphibious assault ship, took place in May 2018. She incorporates several detailed improvements over her sister *Dokdo*. The navy is now examining whether she can be adapted to operate F-35B strike fighters. *(Republic of Korea Navy)*

Also commencing sea trials in 2019 has been the new amphibious assault ship *Marado*, a modified variant of the lead *Dokdo* class ship first commissioned in 2017. Media reports that emerged in the second half of 2018 revealed that the navy is undertaking studies to assess whether either or both vessels can be modified to deploy F-35B strike fighters in similar fashion to the JMSDF's intention for the *Izumo* class. Whilst the more modern *Marado* –

sometimes reported to incorporate a stronger deck more suitable for STOVL operations – would seem the more likely candidate, the design seems a little small to benefit from the F-35B's full potential.

In April 2019, final approval was given to proceed with the purchase of a second batch of KDX-III Aegis-equipped destroyers adapted from the US Navy's *Arleigh Burke* class design. In the longer term, work continues on a new class of KDDX /KDX-IV destroyers that are planned to enter service in the course of the 2030s. Meanwhile, current surface ship construction is focused on smaller FFX-II *Daegu* class frigates, which – although optimised for littoral warfare – are relatively large, well-armed vessels with a full load displacement of 3,600 tons. The last year has seen both DSME and HHI awarded further contracts for a pair each of these vessels, completing the planned eight-ship batch. Unit cost is reportedly around US$280m per vessel but this probably excludes government-furnished equipment. *Daegu* has been in service since March 2018 and a second ship, *Gyeongnam*, was launched by DSME on 21 June 2019.

Other highlights of a busy year include the commissioning of the fourth and final member of the *Cheon Wang Bong* LST-II class, *No Jeok Bong*, in November 2018. *Soyang*, the lead ship of a new class of AOE-II replenishment vessels, joined the fleet during the previous September. In similar fashion to the British Royal Fleet Auxiliary's 'Tide' class, she utilises an innovative hybrid propulsion system allowing both diesel-electric and diesel drive. The Republic of Korea Navy still suffers from limited replenishment-at-sea tonnage and more ships will be required if its blue water aspirations are to be realised.

Soyang, the lead ship of a new class of AOE-II replenishment vessels, is seen during the Republic of Korea Navy's international fleet review in October 2018. She had joined the fleet the previous month. *(Arjun Sarup)*

OTHER REGIONAL FLEETS

Indonesia: Indonesian fleet structure remains split between a small cadre of front-line warfighting vessels and a much larger force of secondary patrol and amphibious units.

Investment in the front-line fleet continues to be dominated by submarine construction. On 11 April 2019, PT PAL launched the country's first indigenously-assembled boat from its facility at Surabaya. The submarine – named *Alugoro* – is the last of three Type 209/1400 boats ordered from South Korea's DSME in 2011 under a contract reportedly valued at over US$1bn. The earlier pair, manufactured by DSME in Korea, have already entered service. The following day, Indonesia signed another US$1bn contract with DSME for a further three submarines. The agreement involves a progressively greater transfer of technology with each boat. When taken together with Indonesia's two existing Type 204/1300 *Chakra* class submarines – which are being modernised by PT PAL with DSME support – the contract will allow Indonesia to meet its target of having

The Indonesian Navy 57m patrol vessels *Layang* and *Kakap*, seen here during exercises with the Royal Australian Navy in the course of 2018, are typical of the large fleet of second-line patrol ships that supplement the fleet's small force of surface combatants. However, many of the larger vessels can be equipped with missiles to give them a warfighting 'punch'. *(Royal Australian Navy)*

eight submarines in service by the mid-2020s.

Modernisation of the surface fleet has largely been carried out by Netherlands-based Damen. Four Dutch-built 'Sigma' 9113 *Diponegoro* corvettes delivered between 2007 and 2009 were followed by delivery of a pair of indigenous-assembled 'Sigma' 10514 *Martadinata* class light frigates in 2017–18. There is an urgent need to replace the six former Dutch *Van Speijk* frigates and further 'Sigma' construction would appear to be a logical next step. However, there have been reports Indonesia is interested in building ships to the larger Danish *Iver Huitfeldt* class design.

Meanwhile, the large second line is benefitting from a steady flow of acquisitions. The four large KCR-60 fast attack craft built by PT PAL will be joined by a further four vessels, more than compensating for the loss by fire of the elderly *Mandau* class *Rencong* on 11 September 2018. The latest PC-40 patrol vessel variant of the KCR-40 *Clurit* fast attack craft design is also attracting orders, with the delivery of the seventh unit, *Albakora*, in July 2018 being quickly followed by orders for the eighth and ninth units. Media reports suggest that there is a total requirement for over forty modern 40m patrol vessels of various types, fewer than half of which have currently been ordered.

The most significant addition to the amphibious force in the last year was the delivery of the improved *Makassar* class landing platform dock *Semarang*, which was commissioned on 21 January 2019. Like the class's South Korean-built prototype, *Dr. Soeharso* (the former *Tanjung Dalpele*), she will be operated as a hospital ship. Construction also continues of the *Teluk Bintuni* class tank landing craft, which are being built to slightly different configurations in three shipyards. *Teluk Lada*, the second of nine vessels ordered to date, was delivered at the end of February 2019.

Malaysia: Malaysia's naval plans continue to be based on the '15 to 5' Transformation Plan that is based on improving future combat effectiveness and cost efficiency by rationalising the fleet's current disparate collection of warship classes. The problem is that the plan's implementation requires significant capital resources at a time when Malaysian defence spending is being subject to significant reductions, falling from around 1.4 percent of GDP in 2016 to just 1 percent of GDP in 2019. A first-ever defence white paper due to be published within the next year may provide a clearer framework on how the country's longer term defence strategy will be funded.

The two main procurement programmes underway are for six *Maharaja Lela* class littoral combat ships and four *Keris* class littoral mission ships. The former are frigate-sized vessels based on Naval Group's 'Gowind 2500' design and are being built by Boustead Naval Shipyard (BNS). Four of the six are under construction following a keel-laying ceremony for *Mat Salleh* in October 2018. Unfortunately, it seems that executing the programme is not going entirely to plan – BNS' parent company has reported heavy financial provisions on the contract – and it is now unlikely that the lead vessel will be delivered this year as planned. Better progress is being achieved with the patrol ship type littoral mission ships. The first was launched by China's Wuchang Shipbuilding in April 2019 and is expected to be delivered before the year's end. It was originally intended to construct two of the four at BNS. Perhaps wisely, the Malaysian government has now decided that all four will be built in China.[13]

New Zealand: The last twelve months have seen two major significant policy developments for the New Zealand Armed Forces. On 6 July 2018 the government published its *Strategic Defence Policy Statement 2018*, essentially the New Zealand coalition's refresh of the 2016 Defence White Paper. Subsequently, in June 2019 a new *Defence Capability Plan 2019* provided a revised procurement programme out to 2030. Both documents have been heavily influenced by New Zealand's 'Pacific Reset', a plan to increase its diplomatic and developmental presence in the region driven partly by fears of growing Chinese influence in its 'back yard'.[14]

The revised plans – which are essentially being carried out within the same NZ$20bn (c. US$13.5bn) capital budget first outlined in 2016 – contain both good and bad news for the Royal New Zealand Navy. Positively, there is a commitment to enhance the navy's sealift capabilities by acquiring a second vessel with greater capabilities than the existing *Canterbury*. The new ship, which will incorporate a dock well, will be ordered in 2026 for delivery before the end of the decade. A decision on replacements for the eight existing Seasprite SH-2G(I) helicopters will be taken during the same year. Procurement of the planned third, ice-capable offshore patrol vessel will be taken forward in 2023 and contracts to replace the two existing offshore patrol vessels will be placed in 2028. However, the planned replacement of the two *Anzac* class frigates will be deferred into the 2030s. This is ostensibly to take full advantage of the mid-life upgrades now taking place but a need to 'smooth' the profile of planned capital spending has probably been the greatest influence. In another instance of 'jam tomorrow, not today', two of the four inshore patrol vessels will be decommissioned in 2020.

June 2019 saw the commissioning of the new diving and hydrographic support vessel *Manawanui*, the former Norwegian commercial offshore support ship *Edda Fonn*. The new replenishment vessel *Aotearoa* was floated out at HII on 24 April 2019. She is expected to arrive in New Zealand early in 2020.

North Korea: The last year has seen the apparent stalling of denuclearisation talks between North Korea and the United States and subsequent reports of test firings of land-based North Korean ballistic missiles for the first time since 2017. However, there has been no news of any significant developments with respect to North Korea's strategic submarine programme. Recent reports suggest ongoing construction of a second submarine, possibly an enlarged sister to the existing sole 'Sinpo' class boat, at the Sinpo South Shipyard but the pace of progress appears to be slow.[15] It is possible continued activity reflects attempts by the Democratic People's Republic of Korea to put pressure on the United States to return to the nuclear negotiating table.

The Philippines: On 23 May 2019, the Philippine Navy marked a significant milestone in its ongoing modernisation efforts with the launch of *Jose Rizal*, the first of a pair of HDF-2600 light frigates modified from the *Incheon/Daegu* designs being constructed by South Korea's HHI. The second ship, *Antonio Luna*, was laid down on the same day. Equipped with SSM-700K Haeseong (C-Star) surface-to-surface and 'Mistal' point defence missiles, the new ships will bring significant new capabilities when deliveries commence towards the end of 2020. A former South Korea *Pohang* class corvette, *Chungju*, is also being transferred as a sweetener to the deal, Renamed *Conrado Yap* after a Philippine officer killed during the Korean War, she is expected to arrive in the Philippines in July 2019. Future items on the shopping list include another

In similar fashion to Indonesia, the Philippines maintain a large force of patrol and amphibious vessels to meet its archipelagic commitments. *Davao del Sur*, seen here in July 2018, is the latter of two *Tarlac* class amphibious transport docks built by Indonesia's PT PAL to a slightly modified version of their *Makassar* design. *(US Navy)*

The Republic of Singapore Navy corvettes *Vigour* and *Valiant* pictured during exercises with the Royal Australian Navy in September 2018. They will be replaced by the new modular multirole combat vessels within the next decade. *(Royal Australian Navy)*

pair of surface escorts and, rather ambitiously, the introduction of a submarine capability.[16]

In similar fashion to Indonesia – and reflecting similar geography – current Philippine naval plans appear to be focused on a split between a small force of major combatants and a much larger fleet of patrol and amphibious assets. The navy has already acquired two *Tarlac* class amphibious transport docks from Indonesia's PT PAL and a tender has now been launched for a second pair of similar vessels. At least one of these must be constructed in the Philippines. A competition is also underway for six new c. 80m offshore patrol vessels, for which Austal, Damen and Lürssen are in contention. Austal is hoping that its possession of a domestic shipyard in Cebu will favour its proposal, which is based on an enlargement of its existing 'Cape' class design.

Singapore: The Republic of Singapore Navy is currently working to complete current modernisation plans whilst starting to prepare for the next generation of projects that will drive the fleet's structure to 2030 and beyond. September 2018 saw the commissioning of the fourth and fifth *Independence* class corvette-like littoral mission vessels *Justice* and *Indomitable*. The eighth and final member of the class, *Fearless*, was launched on 26 January 2019, bringing the project close to a conclusion. The existing *Fearless* class patrol vessels continue to be decommissioned as their replacements enter service.

On 18 February 2019, Professor Ivy Ng, wife of Singapore's Minister of Defence Dr. Ng Eng Hen, named the first Type 218SG submarine *Invincible* at ThyssenKrupp Marine Systems' Kiel shipyard. Two pairs of the boats were ordered in 2013 and 2017, with *Invincible* scheduled for delivery in the course of 2021. Equipped with fuel cell AIP technology, the diesel-electric submarines have an overall length of 70m and have a submerged displacement of c. 2,200 tons.

The next major naval project planned is a new class of multirole combat vessels, which will replace the existing *Victory* class corvettes by 2030. The programme is still in its development phase but appears to be focused on a modular concept optimised around the deployment of a wide spectrum of unmanned vehicles. Further into the future, the existing *Endeavour* class amphibious transport docks will be replaced by larger and more flexible joint multi-mission ships. Media reports suggest there is a good chance that these will be fitted with through decks, possibly supporting F-35B strike fighter deployment.[17]

Taiwan: Although its procurement remains dwarfed by the neighbouring PLAN's massive expansion, Taiwan's Republic of China Navy has made progress with two important programmes over the last year. At the start of May 2019, work commenced on a new industrial facility to support the construction of a new class of indigenous submarines to recapitalise the navy's submarine flotilla. Design work on the new boats started in 2016. This should lead to a production contract before the end of 2020 to allow

The Royal Thai Navy's Korean-built DW-3000 type frigate *Bhumibol Adulyadej* was delivered in December 2018. She is named after Thailand's former monarch, King Bhumibol the Great (reigned 1946–2016). *(US Navy)*

The Vietnamese 'Gepard' type frigate *Ly Thai To* photographed at the ASEAN fleet review in 2017. Vietnam's frigates have been travelling widely in pursuit of defence diplomacy. *(Arjun Sarup)*

delivery of the first unit in 2024. A force of eight submarines is eventually planned.

The same month saw a start on series production of the innovative *Tuo Jiang* catamaran corvettes at the Lung Teh Shipbuilding facility that delivered the prototype ship in 2014. The current contract encompasses an initial batch of three ships that will be delivered from 2021 onwards. Lung Teh is also building a batch of four fast minelayers that will further reinforce the fleet's ability to undertake an asymmetrical defence of the Taiwanese home island against any attack from the mainland.[18]

Thailand: September 2018 saw China's Wuchang Shipbuilding host a formal first steel-cutting ceremony to mark the start of construction of the Royal Thai Navy's lead S26T patrol submarine. Ordered under a c. US$400m contract signed in 2017, the new boat is expected to enter service in 2023. She could be followed by two further submarines in due course. Thailand also has interest in developing a miniature submarine, with the UK's BMT design consultancy reportedly supporting preliminary design efforts.

Meanwhile the surface fleet has been boosted by the arrival of the new DW-3000 frigate *Bhumibol Adulyadej* (formerly *Tachin*). She was handed over by DSME on 14 December 2018 in another sign of South Korea's growing influence in the Asian naval procurement market. Initial plans called for the domestic construction of a second member of the class under technology transfer arrangements. However, this project's current status is uncertain.

Vietnam: The Vietnam's People's Navy has recently completed a major phase of its modernisation programme with the delivery of a total of six Project 636 'Kilo' class submarines and four Project 116661E 'Gepard' type frigates. Whilst a further pair of frigates remain under construction in Russia, it appears that the current focus has switched from procurement to exploiting the capabilities of this new 'green water' fleet. The past year has seen the existing frigates travel as far afield as Japan and Malaysia in pursuit of defence diplomacy, exercising with both friends and potential foes. Whilst China is seen as the main object of this exercise in naval deterrence, some analysts believe insufficient has been done to shore up a generally deteriorating position.[19] Embryonic links with the United States and its partners in the region might help strengthen its options.

Notes

1. See *National Defense Program Guidelines for FY2019 and beyond* (Tokyo: Government of Japan, 2018) available at: http://www.cas.go.jp/jp/siryou/pdf/2019boueikeikaku_e.pdf. Japan's willingness to increase its defences is likely to have been partly influenced by a desire to strengthen American willingness to support the Treaty of Mutual Cooperation and Security between the United States and Japan, which seems to have been put in some doubt by the Trump administration's more transactional take on international security arrangements. For example, see Jennifer Jacobs, 'Trump Muses Privately About Ending Postwar Japan Defense Pact' posted to the *Bloomberg* website on 25 June 2019 at: https://www.bloomberg.com/news/articles/2019-06-25/trump-muses-privately-about-ending-postwar-japan-defense-pact

2. *See Medium Term Defense Program (FY 2019 - FY 2023)* (Tokyo: Government of Japan, 2018) available at: https://www.mod.go.jp/j/approach/agenda/guideline/2019/pdf/chuki_seibi31-35_e.pdf. In contrast to the defense programme guidelines, the medium term defense program takes a shorter, five-year view, looking at the capabilities that will need to be developed or acquired over the period to give effect to the strategic vision.

3. This perspective was taken by *The Japan Times* in an article entitled 'Japan, U.S. and South Korean defense chiefs pledge to work toward North Korean denuclearization' posted to their website on 2 June 2019 at: https://www.japantimes.co.jp/news/2019/06/02/national/politics-diplomacy/bid-move-japan-hints-may-end-talks-radar-lock-issue-south-korea/#.XRJjpehKhUR. An indication of past tensions was provided in October 2018 when the JMSDF withdrew from a Korean Navy international fleet review after being asked not to hoist the 'Rising Sun' flag because of its association with Japan's imperial past.

4. Although the *Hunter* class frigates will start to arrive more quickly than the new *Attack* class submarines, maintaining the capacity of the surface fleet will also pose a challenge to the Royal Australian Navy. It is planned to extend the lives of the existing *Anzac* frigates for between five and ten years to ensure stable fleet numbers. However, a recent report by Australia's auditor general suggests more needs to be done to assess the risks related to this plan, particularly given the class has been subject to higher than anticipated operational usage. See *Auditor-General Report No.30 2018–19L: ANZAC Class Frigates — Sustainment* (Canberra: Australian National Audit Office, 2019) available at: https://www.anao.gov.au/sites/default/files/Auditor-General_Report_2018-2019_30.pdf

5. The task group was led by the amphibious assault ship *Canberra*. It also included *Success* and the *Anzac* class frigate *Parramatta*. The regular deployment of such task groups is starting to supplement the Royal Australian Navy's single-ship operations in a similar fashion to the way the arrival of the *Queen Elizabeth* class will start to influence British Royal Navy deployments.

6. An edited version of the editorial 'Powerful PLA Navy provides solid foundation for China's peaceful development' was posted to the official *China Military Online* site on 24 April 2019 at: http://eng.chinamil.com.cn/view/2019-04/24/content_9486655.htm

7. See Ridzwan Rahmat, 'Beijing criticises increasing presence of extra-regional navies in South China Sea', *Jane's Defence Weekly* – 12 June 2019 (Coulsdon: IHS Jane's, 2019), p.5.

8. *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2019* (Washington DC: Office of the Secretary of Defense, 2019), p.2.

9. Some sources suggest that a number of the widely-used Chinese aircraft carrier designations are incorrect. Under this line of thinking, *Liaoning* has been correctly identified as Carrier or Type 001 but her sister is Carrier 002 rather than Type 001A. Similarly, the third carrier in the early stages of construction at Shanghai is Carrier 003. See Rick Joe, 'A Mid-2019 Guide to Chinese Aircraft Carriers' posted to *The Diplomat* website on 18 June 2019 at: https://thediplomat.com/2019/06/a-mid-2019-guide-to-chinese-aircraft-carriers/

10. An assessment of China's recent lack of transparency was provided by Andrew Tate in 'China's shipyards continue to bolster PLAN's surface fleet', *Jane's Defence Weekly* – 3 October 2018 (Coulsdon: IHS Jane's, 2018), pp.22–3. The article is one of a periodic series using commercial satellite imagery and open source material to assess PLAN construction activity.

11. For an overview of how satellite imagery can be used to assess submarine numbers see Catherine Dill, 'Counting Type 094 Jin-Class SSBNs with Planet Imagery' posted to the *Arms Control Wonk* website on 21 November 2018 at: https://www.armscontrolwonk.com/archive/1206320/counting-type-094-jin-class-ssbns-with-planet-imagery/. Jane's Andrew Tate provides an assessment as to how the methodology might be further improved in the comments section of the post.

12. See 'S. Korean defense budget to be increased 7.5% per year until 2023' posted to the *Hankyoreh* website on 13 January 2019 at: http://english.hani.co.kr/arti/english_edition/e_national/878210.html. Part of the increase is required to support personnel pay and welfare, an increasing problem for the militaries of many formerly emerging economies that have now become more fully developed,

13. For further detail, see Jon Grevatt, 'Malaysia downsizes LMS ambitions', *Jane's Defence Weekly* – 3 April 2019 (Coulsdon: IHS Jane's, 2019), p.3. Malaysia plans an eventual total of twelve littoral combat ships and eighteen littoral mission ships under the '15 to 5' plan but this seems unlikely to be achieved.

14. See further *Strategic Defence Policy Statement 2018* and *Defence Capability Plan 2019* (Wellington: Ministry of Defence, 2018/2019) available respectively at: https://www.defence.govt.nz/assets/Uploads/Strategic-Defence-Policy-Statement-2018.pdf and at: https://www.defence.govt.nz/assets/Uploads/Defence-Capability-Plan-2019.pdf

15. This assessment is based on analysis contained in 'North Korea's Sinpo South Shipyard: Submarine Shipbuilding Continuing at Slow Pace' posted to the *38 North* website on 12 April 2019 at: https://www.38north.org/2019/04/sinpo041219/. 38 North is a project of The Henry L. Stimson Center think tank.

16. A good update on the current state of the Philippine Navy's upgrade programme is provided by Prashanth Parameswaran in 'Philippine Naval Modernization under Duterte in the Spotlight with Anniversary Celebrations' posted to *The Diplomat* website on 20 June 2019 at: https://thediplomat.com/2019/06/philippine-naval-modernization-under-duterte-in-the-spotlight-with-anniversary-celebrations/

17. A more detailed review of the Republic of Singapore Navy's structure and capabilities was provided by Mrityunjoy Mazumdar in *Seaforth World Naval Review 2019* (Barnsley: Seaforth Publishing, 2018), pp.70–81.

18. The start of work on the new ships was covered by Lawrence Chung in an article entitled 'Taiwan starts production of "aircraft carrier killers"', *South China Morning Post* – 24 May 2019 (Hong Kong: South China Morning Post Publishers Ltd, 2019).

19. A good analysis of the limitations of Vietnam's response to Chinese expansionism in the South China Sea is provided by Houng Le Thu in 'Vietnam should update its South China Sea Strategy' posted to the Washington DC based Center for Strategic & International Studies' Asia Maritime Transparency Initiative website on 6 December 2008 at: https://amti.csis.org/vietnam-should-update-south-china-sea-strategy/

2.3 REGIONAL REVIEW

THE INDIAN OCEAN AND AFRICA

Author:
Conrad Waters

Three perennial themes – piracy in the Indian Ocean, instability in the Middle East and the lacklustre performance of the Indian Navy's procurement programmes – have dominated *Seaforth World Naval Review*'s coverage of the diverse Indian Ocean and African region since its first edition. Of these themes, Indian Ocean piracy is now a much-diminished threat as a result of the concerted international action taken to protect the area's trade routes. No ships were hijacked in the region in the whole of 2018 according to the International Chamber of Commerce's International Maritime Bureau.[1] Moreover, 1 May 2019 saw a significant reduction in the extent of the officially designated high risk area for pirate attacks. However, it is not all good news. Piracy actually increased across the world's seas in 2018, largely because of a surge in attacks in the Gulf of Guinea off West Africa where the vast bulk of global piracy is now concentrated.

Whilst shipping in the Indian Ocean is now relatively safe from piracy, May and June 2019 saw a series of attacks on tankers in the Persian Gulf that seem to have been the result of state action. A total of six vessels received damage that was consistent with the detonation of limpet mines, allegedly placed by elements of the Iranian military. Subsequently, on 20 June 2019, an Iranian Revolutionary Guard Corps surface-to-air missile battery shot down a US Navy RQ-4 surveillance drone that Iran claimed had strayed within its airspace.

These events form the latest extensions in the largely proxy war being fought between Iran and Saudi Arabia for influence in the Middle East that has extended from Syria in the north to Yemen in the south. The American Trump administration has increasingly thrown the United States' diplomatic weight behind its Saudi Arabian ally. Notably, it has withdrawn from the so-called Iranian nuclear deal and re-imposed sanctions on Tehran. Many of America's allies take a more nuanced view in the face of heavy civilian casualties resulting from the Saudi-led coalition's air strikes on Yemen and distaste over the extra-judicial murder of the journalist Jamal Khashoggi in the Saudi Arabian consulate in Istanbul. In May 2019, the Spanish government withdrew its frigate *Méndez Núñez* from the *Abraham Lincoln* (CVN-72) carrier strike group when the US Navy flotilla diverted to the Gulf following the first tanker attacks.

The Indian Navy is one of the regional fleets taking a close interest in events in the Middle East. In June 2019 it despatched its destroyer *Chennai* and patrol vessel *Sunayna* to the Gulf to provide reassurance to Indian shipping under Operation 'Sankalp'. The mission is reflective of the navy's aspiration to become the dominant maritime power in the wider Indian Ocean region, a vision backed by a long-term vision to establish a 200-ship fleet. Unfortunately, this seems little more than a pipe dream. At present, the Indian Navy is struggling to maintain current fleet numbers, let alone embark on significant expansion.

The reasons are multifaceted. Although Indian defence spending continues to increase – becoming the fourth highest in the world in 2018 according to SIPRI – nearly sixty percent is allocated to the salary and pensions of nearly five million active and retired personnel. The navy also receives the lowest budget allocation of all three services. Whilst capital expenditure is increasing, it remains inadequate to fund planned programmes. Some analysts have commented that there may be a struggle to meet current contracted commitments, let alone place new orders.[2]

This – along with bureaucratic inertia – may explain why it takes so long to translate programme initiation into firm orders. For example, April 2019 saw the signature of contracts for sixteen new coastal anti-submarine vessels, some five years after requests for proposals were first sought. Industrial infrastructure and, perhaps, expertise also remains an issue in spite of higher shipyard expenditure, possibly because the extended supply chain has yet to catch up. Delayed delivery of the four Project 15B destroyers currently being assembled by Mumbai's Mazagon Dock has been put down to persistent supply chain issue carried over from the preceding Project 15A programme. One consequence is a likely dip in numbers of major surface combatants over the next few years as existing 1980s-era ships reach the end of their service lives. Despite the government's 'Made in India' policy, orders are again being placed in Russia to help bridge the gap.[3]

The elderly Indian Navy *Rajput* class destroyer *Ranvijay* is seen operating in the Indian Ocean in June 2019. Indian Navy force levels are in short-term decline because local industry cannot deliver ships quickly enough to replace all the ships that are reaching the end of their service lives. *(US Navy)*

Table 2.3.1: FLEET STRENGTHS IN THE INDIAN OCEAN, AFRICA AND THE MIDDLE EAST – LARGER NAVIES (MID 2019)

COUNTRY	ALGERIA	EGYPT	INDIA	IRAN	ISRAEL	PAKISTAN	SAUDI ARABIA	SOUTH AFRICA
Aircraft Carrier (CV)	–	–	1	–	–	–	–	–
Strategic Missile Submarine (SSBN)	-	-	1	-	-	-	-	-
Attack Submarine (SSN/SSGN)	–	–	1	–	–	–	–	–
Patrol Submarine (SSK/SS)	6	6	14	4	5	5	–	3
Fleet Escort (DDG/FFG)	2	8	23	–	–	9	7	4
Patrol Escort/Corvette (FFG/FSG/FS)	10	4	11	6	3	–	4	–
Missile Armed Attack Craft (PGG/PTG)	c.12	c.30	8	c.25	8	9	9	3
Mine Countermeasures Vessel (MCMV)	1	c.14	1	–	–	3	3	4
Major Amphibious (LPD)	1	2	1	–	–	–	–	–

Notes:

1 Algerian fast attack craft and Egyptian fast attack craft and mine-countermeasures numbers approximate.

2 Iranian fleet numbers exclude large numbers of indigenously-built midget and coastal submarines, as well as additional missile-armed craft operated by the Revolutionary Guard.

3 The South African attack craft and mine-countermeasures vessels serve in patrol vessel roles.

INDIA

The Indian Navy's current composition is summarised in Table 2.3.2. Overall numbers of fleet escorts have declined by one from twenty-four to twenty-three year-on-year as a result of the decommissioning of the modified Project 61 'Kashin'/*Rajput* class destroyer *Ranjit* on 6 May 2019. Of equal significance was the departure of the final modified Project 266M *Pondicherry* class mine countermeasures vessel *Kozhikode* on 13 April 2019. A deal for replacement minehunters from South Korea's Kangnam Corporation has been cancelled on two separate occasions, resulting in the total loss of a dedicated mine countermeasures capability. Clip-on influence sweeps have been acquired for deployment from patrol vessels until new ships can be built, a process that could take a decade or more to complete.

Major developments with respect to principal warship types are summarised below.

Aircraft Carriers and Amphibious Vessels: The first indigenous aircraft carrier, *Vikrant*, is completing outfitting at Cochin Shipyard Ltd (CSL) and is expected to commence harbour acceptance testing before the end of 2019. The Indian Navy anticipates these will be followed by sea trials in 2020 and delivery in 2021. An extensive period of work-up and aviation trials will then follow before the carrier finally becomes operational in 2023. Whilst plans for a second indigenous aircraft carrier – possibly based on the British Royal Navy's *Queen Elizabeth* class design – remain a key priority, recent press reports suggest lack of funding is proving a major hold-up.

There has, as of yet, been no further progress in letting contracts for four amphibious assault ships under a tender process first launched in 2013. The contract is expected to be placed with a private shipyard. Reliance Naval and Engineering Limited's (RENEL's) Pipavev yard and the Larsen & Toubro conglomerate are said to have been short-listed for the deal. RENEL's proposal is based on France's *Mistral* class whilst L&T are offering a derivative of Navantia's *Juan Carlos I* in a seeming rerun of many previous international competitions.

Surface Combatants: The two main indigenous programmes for major surface combatants comprise four Project 15B *Visakhapatnam* class destroyers allocated to Mazagon Dock Ltd (MDL) and seven project 17A frigates split between MDL (four ships) and Garden Reach Shipbuilders & Engineers (GRSE – three ships). The former programme, essentially an improved variant of the previous Project 15A *Kolkata* class, is the more advanced. Three of the four ships are now in the water following the launch of *Imphal* on 20 April 2019. The keel of the fourth ship, *Porbandar*, was laid the previous July. MDL expects to start delivering the class from 2021 – three years later than initially planned – but this could still prove overly optimistic. The slightly smaller Project 17A frigates – a follow-on from the three Project 17 *Shivalik* class frigates – are anticipated to benefit from modular construction techniques and be delivered between 2022 and 2025. MDL laid the keel of its first ship in December 2017. GRSE followed with its own initial ship on 10 November 2018. However, there are already signs that the schedule is starting to slip, particularly after GRSE's facilities were damaged by the collapse of its new 'Goliath' crane on 17 April 2018.

Given the current state of play, it seems likely that the only major surface combatant likely to be delivered by a domestic yard in the near term is the fourth and final Project 28 *Kamorta* class corvette, *Kavaratti*. She is due to commence sea trials imminently and should be delivered around the turn of the year. The navy has therefore circumvented the 'Made in India' policy by returning to Russia's Yantar yard for a new batch of Project 11356 frigates. Two of these will reportedly be the incomplete *Admiral Butakov* and *Admiral Istomin*, on which work was suspended when Ukraine cut off the supply of their gas turbines. A second pair will be completed by Goa Shipyard Ltd under a technology transfer agreement. Some reports have suggested that this might involve the transfer of a third incomplete hull, *Admiral Kornilov*, for completion in India. The two Yantar-built ships should be available for delivery by 2022–3. It would seem likely that several more years will elapse before they are joined by their Indian sisters.

The Indian Navy's blue water surface combatants have historically been supported by a similarly-sized force of coastal and green water vessels. This is also at risk of erosion as existing ships wear out. The April 2019 award of two separate contracts to CSL and GRSE for a total of sixteen shallow water anti-submarine craft is therefore an important step forward. Both shipyards are required to deliver their first ship before the end of 2023 – 42 months after

India's guided-missile corvette *Kora*, seen here participating in exercises with the Royal Australian Navy in April 2019, is the lead ship of a class of four delivered from the late 1990s onwards. India has ordered a class of sixteen shallow water anti-submarine vessels to bolster the number of second-tier combatants. *(Royal Australian Navy)*

India's fourth 'Scorpène' type submarine *Vela* makes an impressive picture as she is prepared for launch on 6 May 2019. *(Indian Navy)*

contract signing – with deliveries subsequently continuing through to 2026. The reported cost of each contract is UNR63.1bn or approaching US$1.9bn for all sixteen ships. Sketchy details released of the design suggest the ships will have a full-load displacement of c. 750 tons and incorporate waterjet propulsion for a maximum speed in the region of 25 knots.

Submarines: In November 2018 India's Prime Minister Narendra Modi announced that the navy's first strategic submarine, *Arihant*, had undertaken an initial deterrence patrol. Although the voyage marked a significant step forward in Indian ambitions to field a second-strike nuclear capability, much work still needs to be completed to realise this ambition. In common with many other Indian shipbuilding projects, construction of the second strategic submarine, *Arighat*, is running behind schedule. Moreover, delivery of additional boats is likely to stretch much further into the future. In

Table 2.3.2: INDIAN NAVY: PRINCIPAL UNITS AS AT MID 2019

TYPE	CLASS	NUMBER	TONNAGE	DIMENSIONS	PROPULSION	CREW	DATE
Aircraft Carriers							
Aircraft Carrier (CV)	Project 1143.4 **VIKRAMADITYA** (KIEV)	1	45,000 tons	283m x 31/60m x 10m	Steam, 30 knots	1,600	1987
Principal Surface Escorts							
Destroyer – DDG	Project 15A **KOLKATA**	3	7,400 tons	163m x 17m x 7m	COGAG, 30+knots	330	2014
Destroyer – DDG	Project 15 **DELHI**	3	6,700 tons	163m x 17m x 7m	COGAG, 32 knots	350	1997
Destroyer – DDG	Project 61 ME **RAJPUT** ('Kashin')	4	5,000 tons	147m x 16m x 5m	COGAG, 35 knots	320	1980
Frigate – FFG	Project 17 **SHIVALIK**	3	6,200 tons	143m x 17m x 5m	CODOG, 30 knots	265	2010
Frigate – FFG	Project 11356 **TALWAR**	6	4,000 tons	125m x 15m x 5m	COGAG, 30 knots	180	2003
Frigate – FFG	Project 16A **BRAHMAPUTRA**	3	4,000 tons	127m x 15m x 5m	Steam, 30 knots	350	2000
Frigate – FFG	Project 16 **GODAVARI**	1	3,850 tons	127m x 15m x 5m	Steam, 30 knots	315	1983
Corvette – FSG	Project 28 **KAMORTA**	3	3,400 tons	109m x 13m x 4m	Diesel, 25 knots	195	2014
Corvette – FSG	Project 25A **KORA**	4	1,400 tons	91m x 11m x 5m	Diesel, 25 knots	125	1998
Corvette – FSG	Project 25 **KHUKRI**	4	1,400 tons	91m x 11m x 5m	Diesel, 25 knots	110	1989
Submarines							
Submarine – SSBN	**ARIHANT**	1	7,500+ tons	112m x 11m x 10m	Nuclear, 25+ knots	100	2016
Submarine – SSN	Project 971 **CHAKRA** ('Akula II')	1	9,500+ tons	110m x 14m x 10m	Nuclear, 30+ knots	100	2012
Submarine – SSK	Project 75 **KALVARI** ('Scorpène)	1	1,800 tons	68m x 6m x 6m	Diesel-electric, 20 knots	45	2017
Submarine – SSK	Project 877 EKM **SINDHUGHOSH** ('Kilo')	9	3,000 tons	73m x 10m x 7m	Diesel-electric, 17 knots	55	1986
Submarine – SSK	**SHISHUMAR** (Type 209)	4	1,900 tons	64m x 7m x 6m	Diesel-electric, 22 knots	40	1986
Major Amphibious Units							
Landing Platform Dock – LPD	**JALASHWA** (AUSTIN)	1	17,000 tons	173m x 26/30m x 7m	Steam, 21 knots	405	1971

March 2019, it was reported that India had signed a US$3bn deal with Russia to acquire a replacement 'Akula II' nuclear-powered attack submarine to replace the existing *Chakra* once its lease expires. The agreement will allow India to continue to develop the skills needed to operate its own nuclear-powered submarines whilst construction of the indigenous boats continues.

Current conventional submarine construction is focused on the six Project 75 'Scorpène' type boats being built by MDL. Acceptance of the second, *Khanderi*, has been delayed by unresolved but likely minor defects arising during testing. She is unlikely to be delivered before the end of 2019. The third member of the class, *Karanj,* is also undergoing sea trials. A fourth, *Vela*, was launched on 6 May 2019. In January 2019, approval was given to proceed with the long-delayed Project 75(I) for a further batch of six boats with a higher level of indigenous content. Naval Group, Saab, ThyssenKrupp Marine Systems (TKMS) and Russia's Rubin design bureau are all interested in a contract that is still expected to take two to three years to agree. It will therefore not be before the mid-2030s that the programme delivers a meaningful boost to India's underwater strength.

Other Ships: Recent contracts for minor vessels include four survey vessels allocated to GRSE and two diving support vessels. One of the latter will operate with each fleet in conjunction with two deep submergence rescue vessels acquired from the UK's James Fisher Defence. Also imminent is a larger contract for five much-needed fleet support ships that will be built by Hindustan Shipyard Ltd at Visakhapatnam. In May 2019 it was announced that the Turkish TAIS consortium had been selected to design the ships. The development is somewhat surprising given Turkish industry's recent collaboration with India's main regional rival Pakistan in a number of naval projects.

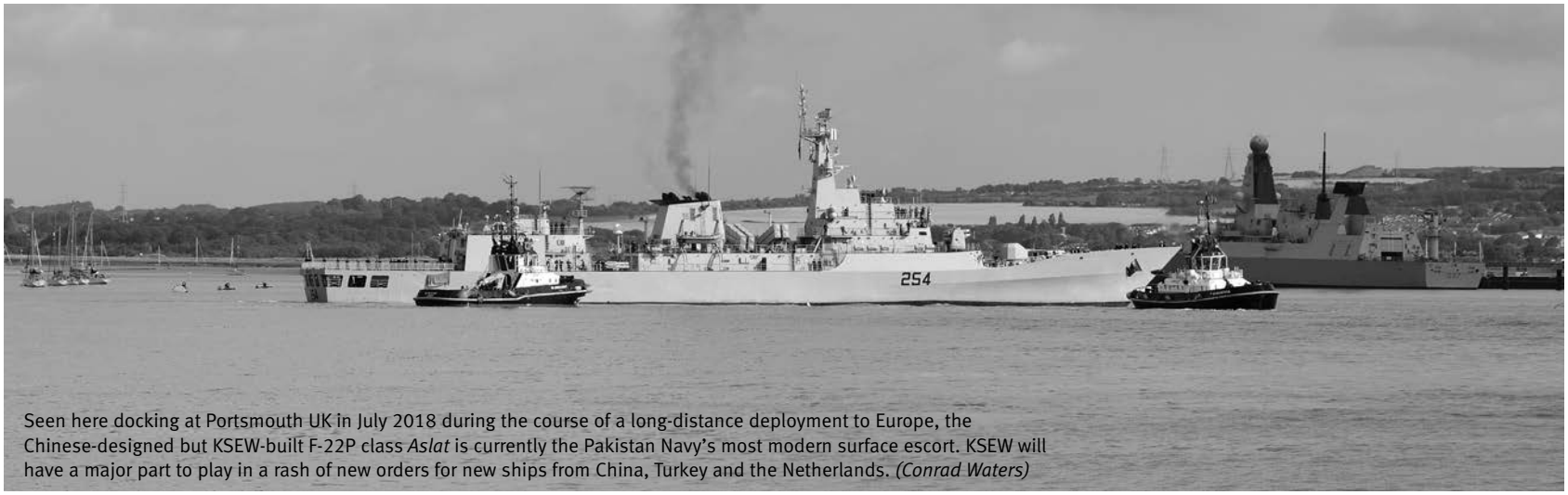
Although it is easy to criticise the often glacial pace of Indian naval modernisation, it is important not to overlook the very real advances that are being achieved by the fleet in areas ranging from the commissioning of new nuclear-powered submarines to the development of a wide range of weapons technologies. One indication of this progress was the navy's recent first surface-to-air engagement utilising cooperative engagement capability. This was demonstrated in May 2019 using the Israeli Barak-8 missile system in a trial firing involving the Project 15A destroyers *Kochi* and *Chennai* in the Arabian Sea.[4] The capacity – previously publicly demonstrated only by US Navy and Royal Australian Navy Aegis-equipped ships – gives the fleet an operational edge possessed by few fleets.

OTHER INDIAN OCEAN NAVIES

Bangladesh: The Bangladesh Navy has recently enjoyed a period of significant modernisation. The most notable development has been the establishment of an embryonic submarine flotilla with the arrival of two second-hand 'Ming' class submarines from China at the start of 2017. These have been supplemented by the transfer of elderly but still useful frigates and coast guard cutters from, respectively, China and the United States, and the commissioning of a number of smaller, new-built vessels. The most recent arrivals have been a second pair of *Shadhinota* CB-13 (Type 056 derivatives) built by China's Wuchang yard. *Sangram* and her sister *Prottasha* were handed over on 28 March 2019. They subsequently arrived at the navy's main Chittagong naval base in April. The two ships are slightly modified variants of the initial pair but none of the four ships have the anti-submarine warfare capabilities inherent in the original Type 056 design.

Myanmar: Myanmar has also been growing its naval capabilities in recent years. It commissioned two locally-built frigates and a corvette in short order between 2014 and 2016. When added to two second-hand Chinese 'Jinaghu II' type frigates acquired in 2012, this more than doubled its flotilla of major surface combatants within the space of five years. Subsequent acquisitions have been focused on second-line patrol and amphibious vessels, possibly reflecting the effort needed to assimilate the larger new vessels into the existing fleet. However, reports suggest the new deliveries form part of a bigger programme of surface-ship construction. A desire to match Bangladesh's underwater capability may also result in the arrival of the country's own submarines during the next decade.

Pakistan: After years of decline, the Pakistan Navy is starting to implement of a raft of new programmes that should halt and, possibly, start to reverse previous reductions in numbers and capability. The



Seen here docking at Portsmouth UK in July 2018 during the course of a long-distance deployment to Europe, the Chinese-designed but KSEW-built F-22P class *Aslat* is currently the Pakistan Navy's most modern surface escort. KSEW will have a major part to play in a rash of new orders for new ships from China, Turkey and the Netherlands. *(Conrad Waters)*

modernisation process is being carried out largely with the help of Chinese and Turkish industry. Once delivered, it holds out the prospect of providing the fleet with meaningful anti-access/area denial (A2/AD) capabilities to deploy against the regionally dominant Indian Navy.

The key to the modernisation programme is the renewal of Pakistan's submarine flotilla. The current five-strong flotilla includes two very elderly 'Agosta 70' class boats and was reported as having only limited operational availability at the time of renewed border skirmishes between India and Pakistan in February 2019.[5] Mid-life updates to at least two of the existing three 'Agosta 90B' submarines are being carried out at Karachi Shipyard & Engineering Works (KSEW) under a contract with Turkey's STM. They will be joined by eight export-variants of the People's Liberation Army Navy's (PLAN's) Type 039A 'Yuan' class that have been ordered from China. The last four will be assembled in Pakistan. This should allow a meaningful uplift in submarine numbers from the present five-boat force from the early 2020s onwards. It is also possible that some of the Chinese submarines will be equipped with nuclear-armed cruise missiles to provide a limited second-strike deterrent capability in response to India's *Arihant* class.

The upgrade to the surface flotilla is also dominated by Chinese and Turkish designs. A total of four PLAN Type 054A-P frigate derivatives will be delivered by 2021, two by KSEW. Both Chinese-built ships are already under construction following a formal first steel-cutting ceremony for the second at Shanghai's Hudong Zhonghua yard in December 2018. Previously, on 5 July 2018, a contract was signed with Turkey for four ships derived from the 'Ada' or 'Milgem' corvette design. Again, two of these will be assembled by KSEW in Pakistan. Deliveries are set to commence in 2023 and will conclude in 2025 with commissioning of the final, Pakistan-built ship. There have been some reports that this ship – to be named *Jinah* – will be an enlarged, frigate-sized vessel possibly influenced by Turkey's *Istanbul.* KSEW is already used to working with Turkish partners, delivering the new STM-designed fleet replenishment tanker *Moawin* in 2018. Commissioned on 16 October, the c. 17,000-ton ship is the largest warship ever completed in a Pakistan yard.

Dutch-based Damen is the other foreign player actively involved in Pakistan's naval market. On 17 May 2019, it launched the first of two new offshore patrol vessels ordered in June 2017 from its yard at Galati, Romania. The new vessel is larger than previously reported at 2,300 tons. It is now described as a multi-role corvette that will be armed with surface-to-surface missiles and other weaponry. Delivery is anticipated within the next twelve months. A second vessel, reportedly to be assembled at KSEW, should follow before the end of 2020.

Sri Lanka: The Sri Lanka Navy's transition from littoral warfighting to longer-range constabulary missions has resulted in a steadily expanding fleet of offshore patrol vessels. The core of this force is the two *Sayurala* class 'advanced offshore patrol vessels' delivered by India's Goa Shipyard in 2017 and 2018. They reinforced a small flotilla of three older patrol vessels that are also largely of Indian origin. However, growing Chinese influence in the country – the cause of a constitutional crisis that saw the temporary dismissal of the country's prime minister in late 2018 – has been reflected in the donation of the former PLAN 'Jinagwei I' frigate *Tonling*.[6] The 'new' ship – arguably the most powerful in the navy's armoury – was handed over at a ceremony in Shanghai in June 2019. The United States is also involved in the three-way tussle for influence in the strategically-important Indian Ocean state. May 2019 saw the arrival in Colombo of *Gajabahu*, the former *Hamilton* class high endurance cutter *Sherman* (WHEC-720). She had been transferred as a gift the previous year, departing for her new home after a period of US-provided maintenance and crew training.

The Sri Lanka Navy's advanced patrol vessel *Sayurala* – seen here with the coast guard's *Surashka* – in March 2019 is one of two Indian-built ships ordered to improve the fleet's ability to conduct long-range constabulary missions. *(US Navy)*

AFRICAN NAVIES

The outlook continues to remain bleak for the only Sub-Saharan navy of any note as **South Africa's** defence budget continues to grow by less than the rate of inflation. Many of the ships and submarines acquired under the large defence contracts negotiated around the turn of the Millennium are now in need of mid-life maintenance. To date, there has only been sufficient funding to pay for the refits of the frigate *Amatola* and the submarine *Manthatisi.* This has impacted the operational availability of the rest of the front-line units. It has essentially been acknowledged that the conclusion of the 2014/15 Defence Review will never be fully implemented.[7]

The ambitious Project Biro for recapitalisation of the patrol vessel fleet has been substantially scaled back. However, at least work has actually commenced on this long-delayed programme. February 23rd 2019 saw Damen Shipyards Cape Town start work on the first of three multi-mission inshore patrol vessels. When completed, they will be based at the re-opened Durban naval base in replacement for the existing re-rolled and life-expired 'Warrior' fast attack craft. Previously, on 30 November 2018, first steel was cut on the Project Hotel hydrographic survey vessel. She is being built at Durban-based Southern African Shipyards to a Vard Marine design.

Naval developments in the rest of Sub-Saharan Africa continue to be dominated by ongoing acquisitions of relatively low-technology patrol vessels to safeguard coastal waters and deeper exclusive economic zones. France has been prominent is this market, as evidenced by further deliveries of OCEA-supplied patrol vessels to **Nigeria** during the course of the year. Another important French player in the African market is Raidco Marine. In April 2019, it was confirmed that **Senegal** had ordered two additional RPB 33 patrol boats from the company to add to a single example supplied in 2013**. Cote d'Ivoire** and **Togo** have also previously purchased the type.

Dutch-based Damen is also active in the African market. One of its more interesting customers is Nigeria's Homeland Integrated Offshore Services. The company operates or has on order a total of eight of the company's Stan Patrol 3307 patrol vessels. They are essentially used to provide private maritime security for oil companies operating in the Gulf of Guinea against the threat of piracy that is ever-present in the region.

As ever, it is activity in North Africa that dominates the continent's naval procurement. **Egypt** has undoubtedly supplanted Algeria as the most ambitious fleet in the region, implementing a massive programme of naval modernisation that has been widely reported to be subsidised by Saudi Arabian funds. France has been the primary beneficiary of this largesse. To date, it has delivered two *Mistral* class amphibious assault ships originally built to Russian order, a FREMM type frigate and a 'Gowind 2500' type corvette. It is also assisting with the assembly of a further three corvettes at Alexandria. Significant elements of equipment for these ships – notably their PSIM (panoramic sensors and intelligence modules) masts – are fabricated in Lorient, with the masts shipped as complete units to Egypt. The first Egyptian ship, *Port Said*, was launched on 7 September 2018. The second, *El Moez*, followed on 19 May 2019. Germany has also become a leading supplier to the Egyptian fleet. It delivered two new Type 209 submarines in 2016 and 2017 and the lead boat of a second pair was launched at Kiel on 3 May 2019. In late 2018 it also became apparent Germany had secured a contract for a flotilla of MEKO A200 frigates in preference to orders for further 'Gowinds'. It appears that a total of six ships is envisaged at a cost of well over €2bn (US$2.3bn).

Algeria's naval modernisation programme continues, albeit now at a somewhat slower pace than Egypt's. The most significant recent arrivals have been two additional Project 636.1 'Kilo' class submarines. They were both delivered in the course of 2018 and formally commissioned as *Ouarsenis* and *Hoggar* at a ceremony at Mers el Kébir on 9 January 2019. The Algerian National Navy now operates a total of six 'Kilos' of different variants and there are unconfirmed reports another pair are on order. The new mine countermeasures vessel programme is also progressing and a second *El-Kasseh* minehunter was launched at La Spezia in December 2018. Various rumours abound with respect to new contracts for larger surface vessels. However, the navy is probably already fully occupied integrating the two MEKO A200 frigates and three Chinese corvettes delivered between 2015 and 2017.

MIDDLE EASTERN NAVIES

Doubtless driven by the troubled security situation, naval procurement in the Middle East also remains relatively buoyant. **Israel** continues to rely heavily on German industry for its new major warships, with TKMS entrusted to deliver both of its most important acquisition programmes. Construction of the second batch of three 'Dolphin II' class submarines is now drawing to a conclusion and the final boat, *Drakon*, is expected to be delivered in 2020. She was originally set to be named *Dakar* after the former 'T' class submarine lost with all hands in 1968 but this was changed after unexpected criticism from families of the original crew. Work is expected to begin on a third batch of three boats to replace the original trio once *Drakon* has been completed.

2020 should also see the delivery of the first SA'AR 6 corvette *Magen*, which was named at TKMS' partner German Naval Yards Kiel's facility on 25 May 2019.[8] With a length of 90m and a beam of 13m, the design has much in common with the German Navy's *Braunschweig* class but will incorporate significant amounts of weaponry and other equipment developed by Israel's indigenous defence industry. A further three ships are expected to be delivered by 2022. The German government has subsidised a third of the construction cost of both the Draken and 'Dolphin II' classes.

Saudi Arabia also has two significant naval construction programmes currently underway. January 15th 2019 saw a first steel-cutting ceremony performed at Navantia's San Fernando yard for the lead vessel in a five-ship corvette programme signed in July 2019. The 'Avante 2200' corvettes will be updated and more heavily armed variants of the four *Guaiquerí* class POVZEE patrol vessels delivered to Venezuela in 2011 and 2012. They are destined to serve alongside four multi-mission surface combatant (MMSC) variants of Lockheed Martin's *Freedom* (LCS-1) class. A number of long-lead items for these ships have already been purchased, with

The Egyptian Navy is building three 'Gowind' class corvettes at Alexandria, where *Port Said* was launched on 7 September 2018. Much equipment –notably the PSIM mast module – is manufactured as a complete assembly in France and then shipped to Egypt for installation. *(Naval Group/Bruno Huriet)*

construction expected to commence at Fincantieri's Marinette Marine yard towards the end of 2019.

Neighbouring **Qatar's** navy is undergoing a massive expansion following the signing of a major contract with Italy's Fincantieri in 2017 for four new 3,250-ton air-defence 'corvettes', two offshore patrol vessels and an amphibious transport dock. Physical work on the ships commenced in the second half of 2018 and has been accompanied by construction of a new Qatar Emiri Naval Forces Base as part of the larger 26.5km^2 New Port Project. The new base encompasses around 200 separate buildings, a helicopter airfield and accommodation for 4,000 personnel. Crewing the new fleet will be a major challenge for a country with fewer than half a million citizens. This suggests that foreign contract workers will be needed to fill out its ranks.

The **United Arab Emirates** have completed a number of major naval programmes in recent years but have recently turned to France's Naval Group for new 'Gowind' corvettes. The contract is believed to encompass two firm and two optional vessels. It will be performed in collaboration with the increasingly ambitious Abu Dhabi Ship Building Company. Although it is not clear which variant of the 'Gowind' series has been selected, the ships are likely to be the largest in the Emirates' fleet.

Fear of **Iran** continues to be the major driver of Middle Eastern naval procurement. The asymmetric A2/AD strategies adopted both by the Islamic Republic of Iran Navy and the independent Iranian Revolutionary Guard Corps Naval Forces in the face of the US Navy's continued regional dominance has meant naval procurement has followed a different trajectory from that adopted by other regional fleets. There has been a particular emphasis on acquisition of a series of indigenously-manufactured submarines of increasing size and sophistication. February 2019 saw the commissioning of the first of the latest of these designs, the lead 600-ton 'Fateh' class boat. The submarine is reported to be equipped with an electro-optical mast and four 533mm torpedoes. Iranian media also claim it can carry two spare torpedoes and up to eight sea mines. Later the same month, one of the previous, smaller 'Ghadir' class submarines was pictured launching a surface-to-surface missile in the course of the 'Velayet 97' exercises in a first for an Iranian submarine.[9] Iran's numerous 'midget' submarines would certainly complicate US Navy and allied operations in the Gulf if current skirmishes developed into a wider conflict.

The new German-built corvette *Magen* is expected to be delivered to Israel's navy in 2020. She is pictured here shortly after launch in May 2019. *(ThyssenKrupp Marine Systems)*

Notes

1. Further detail is provided in the press release 'IMB piracy report 2018: attacks multiply in the Gulf of Guinea' posted to the *ICC* website: icc-ccs.org/ on 16 January 2019.

2. Laxman K Behara's series of annual reviews of Indian defence spending posted to India's Ministry of Defence funded but autonomous Institute for Defence Studies and Analyses provides indispensable analysis of the structure and trajectory of the military's budget. These can be found by searching: https://idsa.in/

3. A lengthy review of current Indian warship procurement was provided by Mrityunjoy Mazumdar in 'Briefing Indian naval shipbuilding: All at sea', *Jane's Defence Weekly* – 19 June 2019 (Coulsdon: IHS Jane's, 2019), pp.24–30.

4. The story 'MRSAM Firing Trials' was released by the India's Press Information Bureau on 17 May 2019 at: http://pib.nic.in/PressReleseDetail.aspx?PRID=1572157&RegID=3&LID=1

5. See, for example, Shishir Gupta and Rahul Singh, 'Only 1 of its 5 submarines operational, Pakistan sends SOS to China' posted to the *Hindustan Times* website on 1 April 2019 available by searching: https://www.hindustantimes.com. Although there may be an element of speculation in the article, Pakistan's underwater capabilities are certainly currently at a low ebb.

6. The crisis reportedly arose when current Sri Lankan President Maithripala Sirisena sacked Prime Minister Ranil Wickremesinghe after a disagreement over whether to allow Indian investment in Colombo's port infrastructure, widely seen as countering a previous Chinese project. Wickremesinghe was eventually reinstated.

7. See 'Defence Review 2015 unlikely to ever be fully implemented' posted to the *defenceWeb* site on 29 November 2018 at: https://www.defenceweb.co.za/sa-defence/sa-defence-sa-defence/defence-review-2015-unlikely-to-ever-be-fully-implemented/. *defenceWeb* remains an excellent source of information on ongoing developments with respect to African navies and the continent's wider militaries.

8. TKMS has previously sold off its surface warship construction yards. Whilst TKMS is understood to be the lead contractor on the *Magen* class contract, it relies on German Naval Yards Kiel to perform physical construction.

9. See Jeremy Binnie, 'Iran shows submarine launching missile', *Jane's Defence Weekly* – 6 March 2019 (Coulsdon: IHS Jane's, 2019), p.15.

2.4 REGIONAL REVIEW

EUROPE AND RUSSIA

Author:
Conrad Waters

Naval headlines in Europe over the past year have continued to be driven by tensions between Russia and its near neighbours. These are most acute on the borders between Russia and Ukraine. Here Russia's 2014 seizure of Crimea has been followed by on/off conflict between Ukrainian forces and Russian separatists in the Donbass region, the latter supported more or less covertly by Russia's military.

On 25 November 2018, another front was opened in this conflict. For some time, Ukraine has been seeking to establish a naval presence in its eastern ports bordering the Sea of Azov. Russia's annexation of the Crimea effectively gives it the means to cut these ports off from the wider Black Sea region, as it now occupies both sides of the Kerch Strait joining the two seas. In May 2018, Russia completed the Crimea Bridge across the strait, thereby linking the annexed peninsula to the rest of Russia. This was followed by increased inspections on Ukrainian commercial shipping using the waterway. In the autumn of 2018, Ukraine commenced passing warships through the strait as part of steps to build a local naval flotilla.

Although an initial transfer of two warships through the strait in September 2018 passed off without serious incident – possibly because Russia had been taken by surprise – a further operation implemented in November was met with force. The small Ukrainian flotilla – the Project 58155 'Gyurza M' class armoured gunboats *Berdyansk* and *Nikopol* and the tug *Yany Kapu* – was first harassed and then halted by Russian forces, which blocked the strait by the simple expedient of placing a cargo vessel under the Crimea Bridge. Later, the Ukrainian vessels were intercepted and captured whilst departing the area after a brief, one-sided engagement in which *Berdyansk* received gunfire damage that wounded three of her crew. The incident marked the first time the Russian military had openly engaged Ukrainian forces since the crisis in the region began.[1]

Responses to the incident have been predictable, with Russia citing Ukrainian provocation and many NATO countries criticising Russia's use of force. It is certainly difficult to understand Ukraine's actions given the reality of the situation on the ground. The twenty-four Ukrainian Navy sailors involved in the incident – all being held as prisoners in a Russian jail – appear to have been used as pawns in a wider political game that may have been influenced by the Ukrainian presidential elections. Equally, Russia's seizure of the ships and sailors follows a pattern of encroachment on Ukraine's sovereignty and a broader disrespect for international norms that has been typical of the Putin era. In May 2019, the International Tribunal for the Law of the Sea ordered the release of both ships and sailors by a majority of 19-1, with only the Russian judge dissenting. To date, Russia has maintained the tribunal does not have jurisdiction over the case.[2]

Russia's ongoing expansionism in the Black Sea has had particular resonance in the Baltic, where many countries share land and maritime borders with their larger neighbour to the east. Strengthening these countries' security has been a key focus of a number of recent initiatives taken by NATO and its partner countries. Amongst these is the UK Joint Expeditionary Force (JEF), which essentially provides a framework under which a group of nations can contribute to a pool of high-readiness forces on a voluntary basis. Led by the United Kingdom, JEF encompasses 'old' NATO partners Denmark, Norway and the Netherlands, 'new' NATO members Estonia, Latvia and Lithuania as well as, interestingly, the militarily non-aligned Finland and Sweden.[3]

The multinational JEF concept was first announced in the second half of 2014 for implementation by 2018. In May 2019 it commenced its first deployment – a series of maritime-focused training exercises – under the 'Baltic Protector' banner. The deployment encompassed a number of operations involving JEF partner members as well as interfaces with other friendly forces, notably as part of the annual US Navy-sponsored BALTOPS exercises. As well as improving inter-operability on a practical level, the exercises – particularly through the selection of a Baltic location – were clearly intended to send a political message of solidarity with partner countries in the region. The wider JEF initiative is also significant in demonstrating the United Kingdom's continued commitment to European security in spite of the ongoing Brexit process.

The Ukrainian Navy 'Gyurza M' artillery boat *Berdyansk* pictured during sea trials in June 2016. *Berdyansk* was one of three Ukrainian Navy vessels seized by Russian forces when they attempted to transit the Kerch Strait between the Black and Azov Seas in November 2018.

TABLE 2.4.1: FLEET STRENGTHS IN WESTERN EUROPE – LARGER NAVIES (MID 2019)

COUNTRY	FRANCE	GERMANY	GREECE	ITALY	NETHERLANDS	SPAIN	TURKEY	UK
Aircraft Carrier (CVN/CV)	1	–	–	1	–	–	–	1
Support/Helicopter Carrier (CVS/CVH)	–	–	–	1	–	–	–	–
Strategic Missile Submarine (SSBN)	4	–	–	–	–	–	–	4
Attack Submarine (SSN)	6	–	–	–	–	–	–	7
Patrol Submarine (SSK)	–	6	11[2]	8	4	3	12	–
Fleet Escort (DDG/FFG)	16	10	13	16	6	11	16	19
Patrol Escort/Corvette (FFG/FSG/FS)	13	5	–	1	–	–	9	–
Missile Armed Attack Craft (PGG/PTG)	–	–	17	–	–	–	19	–
Mine Countermeasures Vessel (MCMV)	14	10[1]	4	10	6	6	11	13
Major Amphibious (LHD/LPD/LPH/LSD)	3	–	–	3	2[3]	3	–	5

Notes:

1 Two further units used as support vessels.

2 Headline figures overstate the actual position, as old ships will be withdrawn once new units are fully operational.

3 Also one joint support ship with amphibious capabilities.

MAJOR REGIONAL POWERS – FRANCE

The French Macron administration established the overall trajectory of the country's future defence policy and procurement through publication of a security review and new military planning law in 2017 and 2018. The last twelve months have seen France move to implement these high-level documents. The consequences for *Marine Nationale* force levels and procurement in major warship categories are outlined below.

France's three amphibious assault ship-like *portes-hélicoptères amphibies* – *Dixmude* is pictured here in October 2018 – have been kept busy whilst France's single aircraft carrier, *Charles de Gaulle*, was undergoing her mid-life refit. *(Derek Fox)*

Aircraft Carriers and Amphibious Ships: The French government's intention is to replace the existing sole carrier *Charles de Gaulle* when she reaches the end of her design life in the 2030s. Preliminary studies have already been underway for several years but further impetus was given to the work with the formal announcement of an 18-month assessment stage at the Euronaval trade fair in October 2018. *Charles de Gaulle* herself has now returned to operational service following completion of a near two-year long reactor refuelling and mid-life modernisation.

Aviation support duties during the carrier's absence were performed by the three *Mistral* class amphibious assault ships, which remain extremely active. In mid-2018, *Dixmude* was one of a number of French vessels that have recently undertaken freedom-of-navigation operations in the South China Sea. Meanwhile construction of the four hybrid amphibious support/patrol ship *d'Entrecasteaux* class vessels has been completed with the delivery of *Dumont d'Urville* by the Naval Group/Piriou Kership alliance on 5 April 2019. Destined for overseas service like her sisters, she will be based in Fort de France, Martinique.

CHANGES IN FRENCH NAVY NOMENCLATURE

In January 2019, the *Marine Nationale* decided to change the nomenclature used to describe several of its warship classes.[1] The new classifications were unveiled in the new online *dossier d'information Marine* (DIM) 2019 and are intended to achieve greater clarity and consistency with respect to their operational assignment. The classifications are also linked to three main groups determined by intended utilisation, viz.

- Combatants with strong offensive capabilities (e.g. aircraft carriers, helicopter carriers and frigates).
- Ships used for patrol and surveillance missions (e.g. surveillance frigates and patrol vessels).
- Ships assigned to a specific purpose (e.g. support and mine warfare vessels).

Amongst the main classes of ships with changed nomenclature are:

Old Designation	New Designation	Anglo-Saxon Equivalent [N2]
Bâtiment de projection et de commandement (BPC)	Porte-hélicoptères amphibie (PHA)	Amphibious Assault Ship (LHD/LHA)
Frégate de taille intermédiaire (FTI)	Frégate de défense et d'intervention (FDI)	Frigate (FFG)
FLOTLOG programme (No designation)	Bâtiment ravitailleur de force (BRF)	Replenishment Oiler (AOR)
Bâtiment multi-missions (B2M)	Bâtiment de soutien et d'assistance outre-mer (BSAOM)	No direct equivalent
Bâtiment de soutien et d'assistance hauturier (BSAH)	Bâtiment de soutien et d'assistance métropolitain (BSAM)	Fleet Ocean Tug (ATF)
Patrouilleur léger guyanais (PLG)	Patrouilleur Antilles Guyane (PAG)	Coastal Patrol Vessel (CPV)

Notes

1. See 'Le dossier d'information Marine (DIM 2019) est en ligne' posted to the Marine Nationale website on 17 January 2019 at: https://www.defense.gouv.fr/marine/actu-marine/le-dossier-d-information-marine-dim-2019-est-en-ligne

2. Author's assessment.

Submarines: Current submarine construction continues to be focused on the 'Barracuda' nuclear-powered attack submarines. The launch of the lead boat of the resulting *Suffren* class is scheduled to be performed on 12 July 2019 at Cherbourg, well over ten years after work first commenced. The last submarine completed for the *Marine Nationale*, the SSBN *Le Terrible*, was launched on 31 March 2008. Although not subject to the same level of media attention, it seems likely that the delays and long-construction times associated with the 'Barracuda' programme are a reflection of a loss of industrial skills similar to those that have afflicted completion of the Royal Navy's *Astute* class boats.

Latest reports suggest *Suffren* will be delivered in 2020 but this will be contingent on the satisfactory completion of the complex process of initial acceptance tests that will follow her launch. However, a start has now been made on withdrawing the previous *Rubis* class that the new submarines will replace. On 21 June 2019, the 35-year-old *Saphir* departed her homeport of Toulon for the final time en route for Cherbourg. There she will be the first of the veteran class to depart the fleet when she is decommissioned in the course of July.

The frigate *Bretagne* is pictured approaching Brest naval base on 19 July 2018, the day after she had been delivered to the *Marine Nationale*. She is the fifth of the type to enter French naval service. *(Bruno Huriet)*

Surface Combatants: The last year has been a busy one for the French element of the FREMM multi-mission frigate programme as the navy transitions towards a slightly reduced force structure based around fifteen major surface combatants.[4] The fifth French FREMM, *Bretagne*, has now entered operational service after delivery in July 2018. She will be followed by her sister, *Normandie*, which has now been completed and was due to depart her building

TABLE 2.4.2: FRENCH NAVY: PRINCIPAL UNITS AS AT MID 2019

TYPE	CLASS	NUMBER	TONNAGE	DIMENSIONS	PROPULSION	CREW	DATE
Aircraft Carriers							
Aircraft Carrier – CVN	**CHARLES DE GAULLE**	1	42,000 tons	262m x 33/64m x 9m	Nuclear, 27 knots	1,950	2001
Principal Surface Escorts							
Frigate – FFG	**AQUITAINE** (FREMM)	6	6,000 tons	142m x 20m x 5m	CODLOG, 27 knots	110	2012
Frigate – FFG	**FORBIN** ('Horizon')	2	7,100 tons	153m x 20m x 5m	CODOG, 29+ knots	195	2008
Frigate – FFG	**CASSARD** (FAA-70)	1	5,000 tons	139m x 15m x 5m	CODAD, 30 knots	250	1988
Frigate – FFG	**GEORGES LEYGUES** (FASM-70)	2	4,800 tons	139m x 15m x 5m	CODOG, 30 knots	240	1979
Frigate – FFG	**LA FAYETTE**	5	3,600 tons	125m x 15m x 5m	CODAD, 25 knots	150	1996
Frigate – FSG	**FLORÉAL**	6	3,000 tons	94m x 14m x 4m	CODAD, 20 knots	90	1992
Frigate – FS[1]	**D'ESTIENNE D'ORVES** (A-69)	7[1]	1,300 tons	80m x 10m x 3m	Diesel, 24 knots	90	1976
Submarines							
Submarine – SSBN	**LE TRIOMPHANT**	4	14,400 tons	138m x 13m x 11m	Nuclear, 25 knots	110	1997
Submarine – SSN	**RUBIS**	6	2,700 tons	74m x 8m x 6m	Nuclear, 25+ knots	70	1983
Major Amphibious Units							
Amph Assault Ship – LHD	**MISTRAL**	3	21,500 tons	199m x 32m x 6m	Diesel-electric, 19 knots	160	2006

Note:

1 Now officially reclassified as offshore patrol vessels. One more to be withdrawn before the end of 2019.

yard at Lorient on 1 July 2019 destined for her assigned homeport of Brest. Previously, Lorient had seen the launch of the seventh ship, *Alsace*, on 18 April 2019. In contrast to her earlier six sisters, she will incorporate a revised outfit of equipment to focus her on the air defence role. A similarly-configured eighth FREMM, *Lorraine*, is in the earlier stages of construction whilst work on the first *frégate de defence et d'intervention* (FDI) will commence in October. The Lorient site is currently undergoing a significant investment phase aimed at reducing construction time from the average of around 48 months for a FREMM to 38 months for a FDI, with as little as 30 months being the ultimate goal.[5]

The arrival of new ships is being counterbalanced by an accelerating pace of withdrawals of older vessels. The fifth FASM-70 frigate *Primauguet* was decommissioned on 1 April 2019, shortly after her FAA-70 half-sister *Cassard* on 15 March.

Patrol Vessels and Auxiliaries: This pattern of steady withdrawals is also reflected in the disposal of second tier-units. July 2018 saw the downgraded A-69 class avisos *Lieutenant de vaisseau Lavallée* and *Commandant L'Herminier* stricken from the fleet. *Lieutenant Le Hénaff* is also due to decommission within the next year. Whilst there is now greater certainty with respect to their replacements following cancellation of the BATSIMAR patrol vessel programme, it will still be some years before these arrive.

BATSIMAR has now been divided into two separate elements that will be carried out in distinct stages. First off the starting block is the acquisition of six *patouilleurs outre-mer* (POM), three pairs of which will serve in French Polynesia, New Caledonia and Réunion. A request for bids launched in August 2018 calls for vessels with a length of 70m and a draught of no more than 3.8m with a core crew of thirty-five personnel and total accommodation for fifty-three. The new ships will need a 30-day endurance and key equipment includes a flight deck and hangar for a large rotary drone, two rigid hulled inflatable boats (RHIBs) and a crane. They will have an extensive communications outfit but only a modest armament. Deliveries are scheduled to take place between 2022 and 2025. They will be followed by ten larger and more capable ships in the late 2020s, which are destined for Metropolitan France. The three *La Confiance* class patrol vessels specifically designed to operate in Guyana and the Antilles will complete a planned force of nineteen vessels. The third of these, *La Combattante*, was christened at Saint-Malo, Brittany in June 2019 and is currently completing trials.

Meanwhile, the renewal of the navy's replenishment fleet was secured with the signature of a contract with a consortium comprising Naval Group and Chantiers de l'Atlantique on 31 January 2019 to acquire four AOR-type logistic support ships. The new ships will be based on the Italian Navy's *Vulcano* design in reflection both of Fincantieri's planned controlling stake in the Chantiers de Atlantique shipyard and ongoing efforts to forge a closer Franco-Italian alliance in warship construction. The latter has not enjoyed an entirely smooth passage given political strains between Paris and Rome but took a further step forward in June with agreement to incorporate a joint venture company that will bid for future domestic and overseas surface warship contracts. However, the deal falls short of the more comprehensive integration – possibly including a share swap – that was envisaged when the deal was first mooted.

Table 2.4.2 provides further details of fleet composition as of mid-2019.

MAJOR REGIONAL POWERS – ITALY

In June 2019, Italy's *Marine Militare* released a public version of its strategic plan through to 2034.[6] Realisation of the plan – the *Linee Di Indirizzo Strategico 2019-2034* – will require a substantial ongoing programme of naval construction to achieve a planned fleet structure based around:

- 1 aircraft carrier.
- 4 major amphibious units (3 new LSSX vessels required in addition to the LHD *Trieste*).
- 4 destroyers (2 new DDX destroyers).
- 10 front-line frigates.
- 15 patrol frigates (8 new corvettes in addition to the 7 *Revel* class PPAs).
- 8 submarines (4 next generation Type 212As).
- 3 logistic support ships (2 additional *Vulcano* class AORs).
- 12 mine countermeasures vessels (4 new oceanic & 8 coastal vessels).

Whilst the *Marina Militare* justifies this structure on

Two computer-generated images of the French Navy's new *bâtiment ravitailleur de force*, which is based on the Italian Navy's *Vulcano* design. Four of these replenishment oilers were ordered from Chantiers de l'Atlantique in Saint Nazaire on 31 January 2019. *(Naval Group)*

Two vivid pictures of the dynamic launch of the Italian Navy's new amphibious assault ship *Trieste*, at the Castellammare di Stabia yard south of Naples on 25 May 2019. She is scheduled for delivery in 2022 after the completion of combat systems integration at Fincantieri's Muggiano shipyard near La Spezia. *(Fincantieri)*

the basis of the essential operational requirements of its fundamental missions, the planned structure appears to be very much in the nature of a 'wish list' given the very substantial influx of funding that will be needed to achieve its aims. The navy's leadership was successful in obtaining exceptional funding for its current construction programme under the 'Naval Law' of 2014/15. However, it is by no means certain such largesse will be forthcoming a second time around.

Meanwhile, good progress is being achieved by Fincantieri in realising the existing programme of

Table 2.4.3: ITALIAN NAVY: PRINCIPAL UNITS AS AT MID 2019

TYPE	CLASS	NUMBER	TONNAGE	DIMENSIONS	PROPULSION	CREW	DATE
Aircraft Carriers							
Aircraft Carrier – CV	**CAVOUR**	1	27,100 tons	244m x 30/39m x 9m	COGAG, 29 knots	800	2008
Aircraft Carrier – CVS	**GIUSEPPE GARIBALDI**[1]	1	13,900 tons	180m x 23/31m x 7m	COGAG, 30 knots	825	1985
Principal Surface Escorts							
Frigate – FFG	**CARLO BERGAMINI** (FREMM)[2]	8	6,700 tons	144m x 20m x 5m	CODLOG, 27 knots	145	2013
Frigate – FFG	**ANDREA DORIA** ('Horizon')	2	7,100 tons	153m x 20m x 5m	CODOG, 29+ knots	190	2007
Destroyer – DDG	**DE LA PENNE**	2	5,400 tons	148m x 16m x 5m	CODOG, 31 knots	375	1993
Frigate – FFG	**MAESTRALE**	4	3,100 tons	123m x 13m x 4m	CODOG, 30+ knots	225	1982
Frigate – FS	**MINERVA**	1	1,300 tons	87m x 11m x 3m	Diesel, 25 knots	120	1987
Submarines							
Submarine – SSK	**TODARO** (Type 212A)	4	1,800 tons	56m x 7m x 6m	AIP, 20+ knots	30	2006
Submarine – SSK	**PELOSI**	4	1,700 tons	64m x 7m x 6m	Diesel-electric, 20 knots	50	1988
Major Amphibious Units							
Landing Platform Dock – LPD	**SAN GIORGIO**	3	8,000 tons	133m x 21m x 5m	Diesel, 20 knots	165	1987

Note:

1 Now operates largely as a LPH.

2 Class includes BERGAMINI (GP) and FASAN (ASW) variants.

fleet renewal. On 25 May 2019, a ceremony was held at the group's Castellammare di Stabia yard south of Naples to celebrate the launch of the new amphibious assault ship, *Trieste*. The ceremony was attended by a host of dignitaries headed by Italian President Sergio Mattarella, whose daughter – Laura Mattarella – acted as the ship's godmother. Expected to have a full load displacement in the region of 33,000 tons, the new ship will supplant *Cavour* as the fleet's largest vessel and is expected to have a secondary aircraft carrier role when *Cavour* is unavailable. The new ship incorporates a twin island structure influenced by that found in the British *Queen Elizabeth* class. Another similarity is the use of Rolls-Royce MT-30 gas turbines as a major part of the propulsion train, albeit in a more conventional combined diesel-electric or gas (CODLOG) arrangement. Preliminary sea trials are expected to commence during 2020. However a second phase of work relating to combat systems integration that will be performed at the group's Muggiano yard near La Spezia means that it will be mid-2022 before the ship is finally delivered.

Concluding a busy period of significant events for Fincantieri, 15 June 2019 saw the naming ceremony for the first frigate-like PPA (*Pattugliatore Polivalente d'Altura*) multi-purpose offshore patrol ship at Muggiano. Named *Paolo Thaon di Revel*, the new ship is similar in size to a FREMM type frigate with an overall length of 143m and a full load displacement of c. 6,000 tons.[7] The class is being built in light, light plus and full configurations of varying combat ability. Whilst the lead ship is one of the less-capable light variants with much 'fitted for but not with' equipment, her main 127mm and secondary 76mm guns – as well as the capacity to embark up to two medium helicopters – give her significant capabilities. Three more ships from an initial order of seven are in various stages of construction.

Fincantieri's yards still remain busy completing the Italian element of the FREMM programme. The eighth unit, *Antonio Marceglia*, was delivered on 16 April 2019 and the ninth and penultimate ship, *Spartaco Schergat*, was launched on 26 January 2019.[8] The FREMMs' arrival is compensating for the ongoing withdrawal of older frigates and corvettes, notably the last operational unit of the *Artigliere* class, *Aviere*, in July 2018. Table 2.4.3 provides an overview of fleet composition as of mid-2019.

The first of Italy's new frigate-like PPA patrol vessels, *Paolo Thaon di Revel*, pictured shortly before a naming ceremony at Fincantieri's Muggiano yard on 15 June 2019. Fincantieri has received orders for a total of seven of these vessels in varying armament configurations. *(Fincantieri)*

MAJOR REGIONAL POWERS – SPAIN

As indicated in Table 2.4.4, there has been little significant change in the composition of the *Armada Española* for yet another year. To a large extent, this reflects the hiatus in new orders that resulted from Spain's financial difficulties during the height of the Eurozone crisis. Two additional BAM type *Meteoro* class offshore patrol vessels were approved in 2014 and these have now joined the fleet. San Fernando-built *Audaz* commissioned on 27 July 2018 and her Ferrol-built sister, *Furor*, followed on 21 January 2019. The Spanish Navy is optimistic that plans to acquire a submarine support and rescue variant of the design – the so-called BAM-IS – to replace the veteran rescue vessel *Neptuno* will be approved shortly.

With Spain's economic fortunes now improving, the future looks considerably brighter. On 23 April 2019 a long-awaited contract was signed for the construction of five new F-110 type frigates under a programme reportedly valued at €4.3bn (c. US$4.8bn). The new frigates – a replacement for the six elderly *Santa María* (FFG-7) class ships – will feature a high level of indigenous content that includes the SCOMBA combat management system. However, the air defence element of their systems will continue to incorporate a significant amount of American technology, including the Aegis system. Construction is anticipated to commence at Navantia's Ferrol yard within the next 12 months and should ensure a continuous workload through to delivery of the last ship in 2031.

Meanwhile, there appears to be more optimism with respect to the badly delayed S-80 Plus submarine programme after a significant uplift in overall funding. In July 2018 it was agreed to raise the budget for the project by a further €1.8bn to €3.9bn or nearly €1bn (US$1.1bn) for each boat. The first unit – *Isaac Peral* – is now expected to be launched in 2021 and should be delivered the following year. The first two boats will be delivered without the class's planned AIP system but this will be installed in the latter pair.

MAJOR REGIONAL POWERS – UNITED KINGDOM

The last year has essentially seen the Royal Navy

Table 2.4.4: SPANISH NAVY: PRINCIPAL UNITS AS AT MID 2019

TYPE	CLASS	NUMBER	TONNAGE	DIMENSIONS	PROPULSION	CREW	DATE
Principal Surface Escorts							
Frigate – FFG	**ÁLVARO DE BAZÁN** (F-100)	5	6,300 tons	147m x 19m x 5m	CODOG, 28 knots	200	2002
Frigate – FFG	**SANTA MARIA** (FFG-7)	6	4,100 tons	138m x 14m x 5m	COGAG, 30 knots	225	1986
Submarines							
Submarine – SSK	**GALERNA** (S-70/AGOSTA)	3	1,800 tons	68m x 7m x 6m	Diesel-electric, 21 knots	60	1983
Major Amphibious Units							
Amph Assault Ship – LHD	**JUAN CARLOS I**	1	27,100 tons	231m x 32m x 7m	IEP, 21 knots	245	2010
Landing Platform Dock – LPD	**GALICIA**	2	13,000 tons	160m x 25m x 6m	Diesel, 20 knots	185	1998

mark time from a policy and procurement perspective as government action has been increasingly impeded by internal and external Brexit discussions. The loss of a further defence minister to political scandal and a pending change of prime minister have only served to solidify the political logjam. By contrast, the fleet has remained extremely active on a worldwide basis in pursuit of the current administration's post-Brexit 'Global Britain' vision.

An estimate of fleet strength is provided in Table 2.4.5. Additions to the Royal Navy fleet have been confined to the second Batch II 'River' class offshore patrol vessel *Medway*. She was handed over on 5 March 2019 but will not be commissioned until September. The third ship, *Trent*, has already completed preliminary sea trials whilst the two final units – *Tamar* and *Spey* – have both been launched. The start of sea trials of the fourth *Astute* class submarine, *Audacious*, appear to have been delayed

The Batch II 'River' class offshore patrol vessel *Medway* pictured entering her homeport of Portsmouth for the first time on 17 June 2019. She is the only new vessel to be delivered to the Royal Navy over the past twelve months. *(Derek Fox)*

Table 2.4.5: BRITISH ROYAL NAVY: PRINCIPAL UNITS AS AT MID 2019

TYPE	CLASS	NUMBER	TONNAGE	DIMENSIONS	PROPULSION	CREW	DATE
Aircraft Carriers							
Aircraft Carrier – CV	**QUEEN ELIZABETH**	1	65,000 tons	284m x 73m x 11m	IEP, 26 knots+	1,600	2017
Principal Surface Escorts							
Destroyer – DDG	**DARING** (Type 45)	6	7,500 tons	152m x 21m x 5m	IEP, 30 knots	190	2008
Frigate – FFG	**NORFOLK** (Type 23)	13	4,900 tons	133m x 16m x 5m	CODLAG, 30 knots	185	1990
Submarines							
Submarine – SSBN	**VANGUARD**	4	16,000 tons	150m x 13m x 12m	Nuclear, 25+ knots	135	1993
Submarine – SSN	**ASTUTE**	4	7,800 tons	93m x 11m x 10m	Nuclear, 30+ knots	100	2010
Submarine – SSN	**TRAFALGAR**	3	5,200 tons	85m x 10m x 10m	Nuclear, 30+ knots	130	1983
Major Amphibious Units							
Landing Platform Dock – LPD	**ALBION**	2[1]	18,500 tons	176m x 29m x 7m	IEP, 18 knots	325	2003
Landing Ship Dock – LSD (A)	**LARGS BAY**	3	16,200 tons	176m x 26m x 6m	Diesel-electric, 18 knots	60	2006

Notes:
1. One at extended readiness.

by an extended period of harbour acceptance tests but she should be delivered in the second half of 2019.[9] By that time the aircraft carrier *Prince of Wales* will also be at sea.

Turning to the Royal Fleet Auxiliary, the second and third 'Tide' class fleet tankers *Tiderace* and *Tidesurge* have now entered operational service. The fourth and final ship, *Tideforce*, will follow shortly.

A more detailed review of the Royal Navy's current programmes and strategic direction is contained in Chapter 2.4A.

MID-SIZED REGIONAL FLEETS

Germany: A detailed review of Germany's *Deutsche Marine* is provided in Chapter 2.4B.

Greece: Significant news with respect to Greece's Hellenic Navy remains sparse. There is clearly a desire to recapitalise the surface fleet. On/off negotiations with France's Naval Group are seemingly increasingly focused on the acquisition of a pair of the 'Belh@rra' export variant of the *Marine Nationale*'s FDI. Funding appears to remain an issue as Greece continues to struggle to rebound from its previous economic crisis. In December 2018 the then defence minister Pantos Kammenos was widely reported as asking wealthy Greeks to fund new warships in a plea that has echoes with the acquisition of the cruiser *Georges Averoff* in the early years of the twentieth century.[10]

There have been no reported changes to the status of the fleet's major units but the operational status of many old and unmodernised ships must be considered doubtful. The only tangible positive news has been confirmation of the long-delayed launch of the sixth of the seven *Roussen* fast attack craft at the Elefsis shipyard on 1 June 2018. It has been reported that additional funding has been provided to complete *Ypoploiarchos Karathanasis* and the seventh vessel, *Ypoploiarchos Vlachakos*, which are now both expected to join the fleet in 2020.

The Netherlands and Belgium: With future fleet structure and related procurement clarified with the publication of the Dutch 2018 Defence White Paper, the *Koninklijke Marine* has been moving ahead with key acquisition programmes. Some of these are being taken forward in conjunction with the Belgian Maritime Component and others are purely national programmes.[11]

The key programmes shared between the two navies are for (i) six new mine countermeasures vessels, and (ii) two new frigates for each fleet. Belgium is leading the mine warfare project, which will replace the partner countries elderly 'Tripartite' class vessels. In March 2019 it was announced that the French-based Belgium Naval Robotics Consortium of Naval Group and autonomous system producer ECA had been selected for the c. €2bn (US$2.2bn) contract. Its proposal – which won out over rival bids from Sea Naval Solutions (comprising Chantiers de l'Atlantique, Socarenam, Thales and EDR) and Damen Imtech – was subsequently confirmed on 22 May. The capability will be based on c. 2,800-ton motherships that will operate at a safe distance from the mined area, deploying a 'toolbox' of unmanned and autonomous underwater vehicles to neutralise the threat. The ships themselves are to be built in Brittany by Naval Group's Kership alliance with Piriou. The first vessel will be delivered to Belgium in 2024, with the lead Dutch ship arriving the following year.

Leadership of the frigate programme is entrusted to the Netherlands. Construction of the ships will be carried out by Damen and they will incorporate a Thales combat system. A number of concept images of the ships have been circulated but a definitive design has yet to be announced. This programme is likely to cost at least a further €2bn.

The most important indigenous Dutch naval programme is for four submarines to replace the existing *Walrus* class. The lack of recent Dutch submarine construction means that these boats will be a variant of a foreign design but construction in the Netherlands is likely. Proposals based on Naval Group ('Barracuda' variant), Navantia (S-80 Plus), Saab (A-26 variant) and ThyssenKrupp Marine Systems (Type 212CD) have been submitted but the Netherlands are apparently struggling to reach a decision against the backdrop of a new, 2018 industrial strategy that seeks to strengthen the local marine sector. The Saab proposal – offered in conjunction with Damen – currently remains the favourite for a contract that should be announced before the end of 2019.

2019 should also see an order placed for a new combat support ship, which will supplement the replenishment capability provided by the existing joint support ship *Karel Doorman*. The new vessel, which is to be named *Den Helder*, will be an evolution of the Damen logistic support vessel design and be able to transfer liquid and solid stores. Construction of the hull is likely to be entrusted to Damen's Romanian yard in Galati, with final outfitting in the Netherlands before delivery in 2022/23.

Turkey: The last year has been marked by growing tensions between Turkey and a number of its NATO partners. Differing interests in the Middle East, conflicting energy claims in the Eastern Mediterranean around Cyprus, and perennial terri-

The Hellenic Navy's 'La Combattante IIIb' fast attack craft S*imaioforos Starakis* pictured on exercises with its *Roussen* class counterpart *Ypoploiarchos Ritsos* in late January 2019. Two further *Roussen* class vessels have been under construction for several years and the sixth, *Ypoploiarchos Karathanasis*, was finally launched in June 2018. Note that *Simaioforos Starakis* carries an experimental camouflage scheme that appears to owe much to the Royal Navy's Second World War disruptive types. *(Hellenic Navy)*

The Belgium Naval Robotics consortium was selected to provide six new mine countermeasures vessels to each of the Royal Netherlands Navy and the Belgian Maritime Component in March 2019. The new vessels are intended to stand clear of mined areas, using a 'toolbox' of unmanned and autonomous vehicles to clear the mine threat. *(Belgium Naval Robotics)*

The Dutch and Belgian navies' 'M' class frigates will be replaced by a new Damen-built design over the next decade. This picture shows the Royal Netherlands Navy's *Van* Speijk in May 2018. *(Marc Piché)*

torial disputes in the Aegean have all added to fears of the closeness of ties between Turkish President Erdogan and the Russian Putin regime. Recent massive naval drills – the largest in the navy's history and encompassing simultaneous deployments in the Mediterranean, Aegean and Black Seas – have doubtless served to convey the message that Turkey is able and willing to protect its maritime interests and borders.

The deterioration in relations with the country's traditional partners has, however, come at a price. As touched upon in the Introduction, the likely cancellation of the United States' sale of F-35 strike fighters due to Turkey's purchase of S-400 surface-to-air missiles from Russia will hit plans to expand the naval air arm. The Turkish Navy had planned to acquire the F-35B short take-off and vertical landing Lightning II variant to deploy from the new amphibious assault ship *Anadolu*. The latter suffered

Commissioned on 4 November 2018, the third indigenous 'Milgem' or 'Ada' class corvette, *Burgazada*, was the most significant arrival in the Turkish fleet over the last year. *(Devrim Yaylali)*

The Ukrainian Navy recently published a strategy paper that places emphasis on controlling its territorial waters, including its ports and inland waterways. This September 2018 picture shows the artillery boat *Berdyansk* exercising with the Romanian river gunboat *Lascăr Catargiu* on the River Danube. *Berdyansk* was seized by Russian forces two months later. *(Ministry of Defence of Ukraine)*

a fire whilst under construction at the Sedef Shipyard, in Tuzla in the early morning of 30 April 2019. It is unclear whether the mishap will push back the ship's planned 2021 delivery date.

The most significant fleet arrival over the past year has been the third 'Ada' class corvette *Burgazada*, which was commissioned on 4 November 2018. The fourth and final member of the class, *Kinaliada*, is likely to join the fleet before the end of 2019. The two ships feature a number of detailed improvements over their earlier sisters. Meanwhile 9 February 2019 saw the launch of the test and evaluation ship *Ufuk*, which appears to have a significant intelligence gathering role. The new vessel has a hull and superstructure based on that of the 'Ada' class but is reported to have an all-diesel propulsion system and no significant armament.[12]

Construction of the new Type 214TN AIP-equipped submarines continues at Gölcük Naval Shipyard, where the launch of the first boat, *Pirireis*, should be imminent. A mid-life modernisation contract for the four Type 209/1400 *Preveze* class submarines was signed in February 2019.

OTHER REGIONAL FLEETS

Black Sea and Mediterranean: Events in the Kerch Strait have overshadowed **Ukraine's** efforts to rebuild a credible naval force after the loss of the bulk of its naval infrastructure following Russia's seizure of the Crimean peninsula. In January 2019 the navy published a *Strategy of the Naval Forces of the Armed Forces of Ukraine 2035* that adopts a phased approach to rebuilding the country's naval forces over the next fifteen years.[13] Citing Russian Federation expansionism as the main threat, the emphasis through to 2025 will be on developing capabilities to establish control over territorial waters up to around 40 nautical miles from the coast. The top priority is to develop efficient maritime domain awareness in this coastal zone, followed by the acquisition of sea denial and, subsequently, sea control capabilities. During 2025–2030 attention will shift to Ukraine's exclusive economic zone, with initial intelligence-gathering capacity expanding to the creation of sea control and strike forces. A third, more ambitious stage will see the navy develop the ability to deploy at greater distances. The initial stages of this strategy fit well with the continued creation of the 'mosquito fleet' of small craft typified by the Project 58155 'Gyurza M' armoured gunboats that played a key part in the Kerch Strait incident. Four of these are now in service in addition to the two detained by Russia, with a further three in various stages of construction.

Neighbouring **Romania** continues to progress longstanding plans to modernise the core of its navy through the acquisition of new corvettes and the upgrade of its two existing Type 22 frigates. It was long thought that Damen's strong industrial presence in the country through ownership of the Galati shipyard would result in the selection of the company's 'Sigma' type vessels for the deal. However, recent media reports suggest that a competing Naval Group proposal based around its 'Gowind' design is now favourite. An order for four ships is believed to be imminent. **Bulgaria** also has an enduring requirement for two corvette-like 'multi-function' patrol vessels, restarting the procurement process in 2018 after a previous deal with local yard MTG Dolphin collapsed when tax changes reduced the value of the order. MTG Dolphin has now been joined by Lürssen and Fincantieri in bidding for the order, which should be placed before the year's end.

Turning to the Mediterranean, a continued fall in overall illegal migration into the European Union has masked a shift in the main transit routes towards the sea's western shores in the face of a hard-line Italian stance to the influx of refugees. Although reduced, fatalities amongst those making the crossing remain high as the European Union's Operation 'Sophia' has increasingly switched emphasis away from rescue towards discouraging migrants from making the risky crossing. **Malta** has been one of the smaller countries in the forefront of the crisis; an undoubted influence in its acquisition of a new offshore patrol vessel with the support of EU funding. The €49m contract has been placed with Italy's Cantiere Navale Vittoria, which will deliver the new vessel in 2020. With an overall length of 75m and a displacement of c. 1,800 tons, the ship will incorporate a flight deck for a light helicopter and launch positions for two RHIBs but only be lightly armed.

Atlantic: The award of the Maltese contract marked the end of shipbuilding at the British Babcock group's Appledore yard, which was an unsuccessful bidder for the order. The shipyard closed following the completion of *George Bernard Shaw*, the final

The Royal Norwegian Navy's *Fridtjof Nansen* class frigate *Helge Ingstad* collided with the Maltese-flagged tanker *Sola TS* near Bergen in the early hours of 8 November 2018. Uncontrollable flooding resulted in the frigate being abandoned after losing steerage and running aground following the accident. She subsequently slipped into deeper water and, within days, only her mast was visible. Subsequently salvaged in February and March 2019, the frigate has been assessed as being beyond economic repair. *(Norwegian Armed Forces/Marius Villinger & Jakob Ostheim)*.

member of a class of four *Samuel Beckett* class offshore patrol vessels built for **Ireland**. The new ship was officially commissioned at a ceremony in Waterford on 30 April 2019. The Irish Naval Service is, however, finding it difficult to find sufficient sailors to crew its new vessels after years of austerity-induced pay restraint. In June 2019 it emerged that the Irish flagship patrol vessel, *Eithne*, and the smaller *Orla* would be laid up indefinitely to provide sufficient manpower for the rest of the fleet.

The situation in **Portugal** is rather more positive. The fleet continues to be balanced between a small warfighting component – two submarines and five frigates – and a much larger constabulary element, the latter focused on policing the country's extensive economic zone in the Atlantic. Renewal of the latter effectively stalled during the Eurozone's financial crisis but is now back on track. The last year has seen deliveries of *Sines* and *Sétubal*, the second pair of *Viana do Castelo* class offshore patrol vessels ordered from West Sea Viana Shipyard in 2015.The success of the restarted construction programme was reflected in an announcement by Portuguese premier António Costa at *Sines*' commissioning ceremony that the offshore patrol vessel programme would be expanded to a total of ten units, with the additional six to be funded in the next military programming law. Each ship is expected to cost €60m and take around two years to complete. A new multi-purpose logistic support ship will also be purchased at a cost of €150m to replace the veteran *Bérrio*. In effect, the announcement means that replacement of the old corvettes that were re-rolled as patrol ships will now take place on a one-for-one basis. Only two of these remain in service following the decommissioning of *Jacinto Cândido* in November 2018.[14]

Scandinavia and The Baltic: The most dramatic news impacting Scandinavia's navies in the last year has undoubtedly been the loss of **Norway's** *Fridtjof Nansen* class frigate *Helge Ingstad.* The frigate was

The Swedish submarine *Gotland* commenced sea trials in November 2018 following completion of a mid-life refit and modernisation that included insertion of a new 2m hull section, updated Stirling AIP modules, sensor enhancements and installation of a modern optronic mast. Many of these technologies will also be incorporated in the new A26 class. *(Copyright Saab AB)*

on a southerly course heading for its homeport of Bergen when it collided with the Maltese-flagged oil tanker *Sola TS* off the Sture oil terminal just after 04.00 in the early morning of Thursday, 8 November 2018. Three or four of the ship's thirteen watertight compartments rapidly flooded after the collision and control of the rudder and propulsion system were lost. The frigate grounded around ten minutes later and was subsequently abandoned after the stuffing boxes in the bulkheads failed to prevent the uncontrolled ingress of water via the shaftlines entering the main machinery spaces. Fortuitously, no lives were lost as a result of the accident. Whilst no definitive conclusions have yet been reached as to the causes of the accident, a preliminary report by the Accident Investigation Board Norway suggests there was considerable confusion on *Helge Ingstad*'s bridge immediately before the collision.[15]

Subsequent days saw the frigate sink into deeper water, where it remained until salvaged in a complex operation during late February and March 2019. After surveys suggested it would cost between NOK12–14bn (US$1.4bn to US$1.6bn) – more than a new build replacement – to repair the ship, the Norwegian Ministry of Defence accepted a recommendation that *Helge Ingstad* was beyond economic repair. Various options are being examined as to how to make good the lost capability, which reduces the Royal Norwegian Navy's frigate force to just four ships. In the interim, the frigate's crew is being used to increase the operational availability of the other frigates and of the new logistic support vessel *Maud*, which was commissioned at Bergen towards the end of May.

Sweden is currently in the course of a periodic defence review that will probably see final plans for defence posture in the 2021–2025 period announced early in 2020. A report by Sweden's cross-party Defence Commission presented in May 2019 recommends a significant rise in defence spending and an increase in conscription to achieve a more resilient defence structure that owes something to the Finnish comprehensive security model.[16]

The commission's proposals for the Swedish Navy are weighted more towards the upgrade and eventual replacement of existing units than a major increase in force levels. However, it does recommend increasing the fully-operational submarine flotilla to five boats. If accepted, this proposal would suggest the current midlife updates of *Gotland* and *Uppland* will be extended to the third member of the *Gotland* class, *Halland*. Physical work on the two submarines that have already entered the modernisation programme has now been completed following *Uppland*'s relaunch on 19 June 2019. The new A26 class boats that are currently under construction will make up the rest of the underwater force. In January 2019 it was announced these would be named *Blekinge* and *Skåne*.

The renewal of the corvette flotilla is someway further off, although the commission recommends replacing the two *Gävle* class vessels sometime after 2025. New surface-to-surface and surface-to-air missiles are proposed for the five more modern *Visby* class corvettes that comprise the balance of the flotilla. The surface fleet is also set to receive a more immediate upgrade in the form of the intelligence vessel, *Artemis*. She was launched by the Polish Nauta Ship-repair Yard in April 2019 and will be outfitted by Saab in Sweden before delivery in 2020.

Elsewhere in Scandinavia, a detailed review of **Finland's** navy is provided in Chapter 2.4C. **Denmark's** political parties signed a new Defence Agreement for the period 2018–2023 in January 2018 that included the acquisition of SM-2 missiles for the *Iver Huitfeldt* class frigates. It is unlikely that these plans will be altered by the change in government that took place in June 2019.

Poland's naval modernisation programme continues to proceed in fits and starts. There are few signs of tangible progress with the replacement submarine programme whilst the only major new ship to be delivered from a series of surface projects has been the lead 'Kormoran II' minehunter *Kormoran* in 2017. *Albatros*, the second of a planned three-ship programme was laid down by Renontowa Shipbuilding in December 2018 and work should start on a third in the coming year.

The long-delayed MEKO-100 based patrol vessel *Slàzak* – essentially a corvette – has also finally commenced sea trials, departing Gdynia for the first time on 14 November 2018. Delivery is scheduled for the second half of 2019. Another positive development is the award of a contract for four Anglo-Italian AW-101 helicopters under a €380m

(US$42rm) deal. Deliveries will be concluded by 2022 but could be followed by additional orders.

RUSSIA

The future trajectory of the Russian Navy has been established by the State Armaments Programme for 2018–2027 (GPV 2027), which was more fully analysed in last year's edition. In overall terms, GPV 2027 attempts to match Russian defence spending with economic realities to allow sustainable defence modernisation. In contrast with the Soviet-era focus on overwhelming military mass, there is a more intelligent channelling of limited funds into the acquisition of high-technology equipment in priority areas. For the navy, this means a continued focus on submarines for both nuclear and conventional deterrence coupled with investment in powerful anti-access/area denial (A2/AD) surface forces intended largely for deployment in the littorals.[17]

One consequence of this approach has been the scaling back of grandiose schemes for a new fleet of 'blue water' surface combatants. In practice, oceanic commitments will continue to be met by elderly but modernised Soviet-era combatants supplemented by a handful of new frigate-sized ships. The first ship of this new generation – the Project 22350 frigate *Admiral Gorshkov* – was finally commissioned on 28 July 2018. She has subsequently embarked upon a global circumnavigation – visiting ports in the Indian Ocean, Pacific and Caribbean – in an exercise intended to demonstrate both the durability of her systems and also the advances achieved in Russian naval technology to friends and foes alike.

The deployment of this new technology continues to take time to deliver and it is not entirely clear that industry has yet overcome production difficulties exacerbated by the cessation of deliveries of key equipment from Ukraine. Table 2.4.6 therefore shows little in the way of significant change to principal fleet units from last year. However, there are two important caveats. One is the progress now being achieved in commissioning a new generation of smaller but powerfully-armed warships in line with the littoral A2/AD focus outlined above. The other is the number of programmes that are now close to delivering additional ships; progress which is likely to be reflected in next year's edition. In the meantime, an overview of key programmes is provided below.

Submarine Construction: There has been no change in the composition of Russia's strategic submarine flotilla year-on-year. There have, however, been various reports that the first Project 955A 'Borey II' submarine, *Knyaz Vladimir*, commenced sea trials in late 2018. This would put her on track for delivery around the end of 2019. A further four Project 955As are under construction for delivery by 2023. Conflicting reports suggest

TABLE 2.4.6: RUSSIAN NAVY: SELECTED PRINCIPAL UNITS AS AT MID 2019

TYPE	CLASS	NUMBER[1]	TONNAGE	DIMENSIONS	PROPULSION	CREW	DATE
Aircraft carriers							
Aircraft Carrier – CV	Project 1143.5 **KUZNETSOV**	1	60,000 tons	306m x 35/73m x 10m	Steam, 32 knots	2,600	1991
Principal Surface Escorts							
Battlecruiser – BCGN	Project 1144.2 **KIROV**	1 (1)	25,000 tons	252m x 29m x 9m	CONAS, 32 knots	740	1980
Cruiser – CG	Project 1164 **MOSKVA** ('Slava')	3	12,500 tons	186m x 21m x 8m	COGAG, 32 knots	530	1982
Destroyer – DDG	Project 956/956A **SOVREMENNY**	c.2	8,000 tons	156m x 17m x 6m	Steam, 32 knots	300	1980
Destroyer – DDG	Project 1155.1 **CHABANENKO** ('Udaloy II')	1	9,000 tons	163m x 19m x 6m	COGAG, 29 knots	250	1999
Destroyer – DDG	Project 1155 **UDALOY**	c.8	8.500 tons	163m x 19m x 6m	COGAG, 30 knots	300	1980
Frigate – FFG	Project 22350 **GORSHKOV**	1	5,500 tons	135m x 16m x 5m	CODAG, 30 knots	210	2018
Frigate – FFG	Project 11366M **GRIGOROVICH**	3	4,000 tons	125m x 15m x 4m	COGAG, 30 knots	200	2016
Frigate – FFG	Project 1154 **NEUSTRASHIMY**	2	4,400 tons	139m x 16m x 6m	COGAG, 30 knots	210	1993
Frigate – FFG	Project 1135 **BDITELNNY** ('Krivak I/II')	c.2	3,700 tons	123m x 14m x 5m	COGAG, 32 knots	180	1970
Frigate – FFG	Project 2038.0 **STEREGUSHCHY**	6	2,200 tons	105m x 11m x 4m	CODAD, 27 knots	100	2008
Frigate – FFG	Project 11611 **TATARSTAN** ('Gepard')	2	2,000 tons	102m x 13m x 4m	CODOG, 27 knots	100	2002
Submarines							
Submarine – SSBN	Project 955 **YURY DOLGORUKY** ('Borey')	3	17,000+ tons	170m x 13m x 10m	Nuclear, 25+ knots	110	2010
Submarine – SSBN	Project 941 **DONSKOY** ('Typhoon')	1	33,000 tons	173m x 23m x 12m	Nuclear, 26 knots	150	1981
Submarine – SSBN	Project 677BDRM **VERKHOTURYE** ('Delta IV')	6	18,000 tons	167m x 12m x 9m	Nuclear, 24 knots	130	1985
Submarine – SSBN	Project 677BDR **ZVEZDA** ('Delta III')	1	12,000 tons	160m x 12m x 9m	Nuclear, 24 knots	130	1976
Submarine – SSGN	Project 855 **SEVERODVINSK** ('Yasen')	1	13,500 tons+	120m x 14m x 9m	Nuclear, 30+ knots	90	2013
Submarine – SSGN	Project 949A ('Oscar II')	c.5	17,500 tons	154m x 8m x 9m	Nuclear, 30+ knots	100	1986
Submarine – SSN	Project 971 ('Akula I/II')	c.10	9,500 tons	110m x 14m x 10m	Nuclear, 30+ knots	60	1986
Submarine – SSK	Project 677 **ST PETERSBURG** ('Lada')	1	2,700 tons	72m x 7m x 7m	Diesel-electric, 21 knots	40	2010
Submarine – SSK	Project 877/636 ('Kilo')	c.20	3,000 tons	73m x 10m x 7m	Diesel-electric, 20 knots	55	1981

Notes:

1 Table only includes main types and focuses on operational units: bracketed figures are ships being refurbished or in maintained reserve.

between two and six additional strategic submarines will be built at a later date, which – combined with the existing three Type 955 'Borey' boats – would achieve a modernised underwater deterrent of between ten and fourteen units. The RSM-56 'Bulava' ballistic missile that arms the submarines was reportedly officially accepted into service in June 2018 after a successful four-missile salvo was launched from the lead Type 955 'Borey' *Yuri Dolgoruky* during the previous month.

Production of the Project 955A submarines at Sevmash's Severodvinsk plant has taken priority over the Project 855M 'Yasen' class attack submarines. The first of these – an improved variant of the prototype Project 855 *Severodvinsk* – started trials in September 2018. Unspecified technical problems, possibly related to her missile-launching systems, have delayed her acceptance and she is not now planned to enter service until 2021. This will doubtless have a knock-on effect on the other five members of the class that are currently under construction. In spite of this setback, the Russian Ministry of Defence appears to have confidence in the project and an order for two further submarines of the type was placed in June 2019.

Sevmash has also been working on a third programme that has involved the conversion of an incomplete Project 949A 'Oscar II' attack submarine hull into a specialised drone mothership. The new submarine – named *Belgorod* – was launched in a secretive ceremony on 23 April 2019. The submarine is intended to deploy the new Poseidon unmanned underwater vehicle, which is reported to have an intercontinental range and be capable of carrying a nuclear payload. The stated intent behind the new weapon is to counter the danger that Russia's existing ballistic-missile based nuclear deterrent will be undermined by American investment in missile defence systems.[18]

Diesel-electric submarine construction remains focused on both Project 677 'Lada' and Project 636 'Kilo' types. Progress is now being made with the long-delayed 'Lada' class project. *Kronshtadt*, the second, much-modified boat in the class, was launched at St. Petersburg's Admiralty Shipyard in September 2018 where a third unit is also under construction. Contracts for two additional members of the class were announced in June 2019, suggesting past problems with the design have been overcome. However, Admiralty Shipyard continues to work on the second batch of six Project 636.3 submarines that were ordered to prevent the 'Lada' class delays impacting overall force levels. *Petropavlovsk-Kamchatsky*, the first of this batch, was launched on 28 March 2019.

The third Russian Project 11356 *Admiral Grigorovich* class frigate *Admiral Makarov* transited the English Channel en route for Russia's Black Sea fleet in August 2018. It seems no other ships of the class will be completed for Russian service given their Ukrainian-supplied gas turbines are now unobtainable. *(Crown Copyright 2018)*

Surface Combatant Construction: Construction of large surface combatants is increasingly focused on the Project 22350 *Admiral Gorshkov* class. With the lead ship now delivered, attention is turning to completing the three follow-on ships that were laid down between 2009 and 2013. The first of these, *Admiral Kasatonov*, commenced preliminary trials towards the end of 2018 and the next, *Admiral Golovko*, should be launched this year. The keels of two additional vessels were laid at a ceremony attended by Russia's President Putin on 23 April 2019. These are to receive improvements over the earlier quartet but probably do not mark the transition to the enlarged Project 22350M variant, which has been under design for some time. Meanwhile, the decision to sell the fourth and fifth Project 11356 *Admiral Grigorovich* class frigates to India probably marks the end of the type's construction for the Russian Navy. There is also a sixth, incomplete hull at the Yantar yard in Kaliningrad that – like the earlier ships – is laid up for want of Ukrainian-sourced gas turbines. Ukraine is reportedly willing to supply these for the ships that will be delivered to the Indian Navy buy not for any being completed for Russia.

Construction of smaller surface combatants continues to be typified by orders for a diverse range of different types from a wide range of yards. Current programmes can be summarised as:

- **Project 20380 *Steregushchy*:** Six light frigate-sized ships delivered by the Severnaya Verf and Amur yards from 2008 to 2018. Four more are under construction; two at each shipyard.
- **Project 20385 *Gremyashchy*:** An improved, slightly enlarged *Steregushchy* variant. Production was truncated when sanctions hit the supply of Western-supplied engines but two remain under construction at Severnaya Verf with substitute Russian-built diesels. The lead ship is currently undergoing trials.
- **Project 20368 *Merkuriy*:** Formerly known as *Derzkiy*, this is a further development of the original Project 20380 concept featuring a composite stealth structure, new weapons and a mission bay for modular systems. It can essentially be considered a new design. The prototype is currently being built at Severnaya Verf.
- **Project 21361 'Buyan M':** Developed from the three previous Project 21360 'Buyan' gunboats designed for service on the Caspian Sea, these are relatively small, cruise-missile armed ships intended for anti-shipping and land attack warfare in the littorals. Seven have been delivered from the inland Zelenodolsk yard, which is completing a further five of the type.
- **Project 22800 'Karakurt':** A similarly-sized but more seaworthy design than the 'Buyan M', these are also optimised for anti-surface warfare. The lead ship, *Mytishchi* (formerly *Uragan*), was delivered in December 2018, only three years after assembly had commenced. The programme is being pushed ahead with some urgency and seventeen other ships are either under construction or on order from a total of six shipyards.

Other significant construction programmes include the Project 22160 offshore patrol ships and larger Project 23350 Arctic patrol ships. The first two Project 22160 class vessels – *Vasily Bykov* and *Dmitriy Rogachev* – have already joined the fleet and should be followed by four more by 2022. The two Arctic patrol ships are somewhat less advanced but will also be operational by the middle of the decade. Although nominally lightly armed, both designs are equipped to accommodate modular containers that could, for example, house Kalibr cruise missiles.

Other Programmes: The modernisation programme for the sole aircraft carrier *Admiral Kuznetsov* suffered a significant setback when the dock she was being refurbished in sank after an industrial accident in October 2018. It appears an alternative facility will be upgraded to complete the work but this will come at the cost of the additional expense and time. The modernisation of the battlecruiser *Admiral Nakhimov* is also reportedly running behind schedule, highlighting the significant challenges inherent in keeping an often-neglected cadre of Soviet-era ships operational.

The renewal of the amphibious fleet has taken another *volte face* that is not entirely unusual in Russian naval procurement with the decision to extend production of the Yantar-built Project 11711 *Ivan Gren* class landing ships. In a ceremony timed to coordinate with the start of new *Gorshkov* class frigate production and the launch of the submarine *Belgorod*, two additional ships were laid down at Kaliningrad on 23 April 2019. The new ships – *Vasily Trushin* and *Vladimir Andreev* – will be a modified and enlarged design with enhanced helicopter operating provision similar to that provided by an LPD-type amphibious transport dock. The decision possibly reflects the postponement of plans for larger ships under GPV 2027 and a desire to use the expertise at Yantar to greatest effect.

Notes

1. A good analysis of the Kerch Strait incident and the relative accuracy of Russian and Ukrainian accounts is provided by Michael Cruickshank in 'Investigating the Kerch Strait Incident' posted to the *bellingcat* investigative website on 30 November 2018 at: https://www.bellingcat.com/news/uk-and-europe/2018/11/30/investigating-the-kerch-strait-incident/

2. The International Tribunal for the Law of the Sea is an inter-governmental organisation that was established under the United Nations Convention on the Law of the Sea, which came into force in 1994. It gives warships and their crews immunity from detention. Russia argues that its signature of the Convention was subject to a reservation excluding the Tribunal's jurisdiction from matters that directly concerned national sovereignty and security and it is therefore not applicable in the Kerch Strait case.

3. For a good Scandinavian view of the JEF see Håkon Lunde Saxi, 'The UK Joint Expeditionary Force (JEF)' posted to the Department of Defence Studies section of the Norwegian Armed Forces website on 18 May 2018 at: https://forsvaret.no/ifs/Publikasjoner/ifs-insights-kronologisk-(2010-)/saxi-the-uk-joint-expeditionary-force-(jef)

4. There is some confusion over French plans for future major surface combatant numbers. The *Military Planning Law 2019/2025* suggests a force of seventeen in 2025, viz. 2 x 'Horizon', 8 x FREMM, 5 x *La Fayette* and the first two FDI. However, it appears this total will subsequently fall to fifteen when the last three FDI are delivered, replacing all the *La Fayette* class.

5. See Vincent Groizeleau, *Lorient ambitionne de construire une frégate en 30 mois et une corvette en 20* posted to *Mer et Marine* on 9 May 2019 at: https://www.meretmarine.com/fr/content/lorient-ambitionne-de-construire-une-fregate-en-30-mois-et-une-corvette-en-20

6. *Linee Di Indirizzo Strategico 2019-2034* (Rome: Marina Militare, 2019) available by searching: http://www.marina.difesa.it

7. Admiral Paolo Thaon di Revel (1859–1948) was an Italian naval officer and politician holding senior roles that included Chief of the Naval Staff, Minster of the Navy and President of the Italian Senate.

8. Captain Antonio Marceglia (1915–92) and Chief Petty Frogman Spartaco Schergat (1920–96) were *maiale* underwater assault vehicle operators who seriously damaged the British Royal Navy battleship *Queen Elizabeth* in the raid on Alexandria harbour in December 1941.

9. The delay to *Audacious*' sea trials is noteworthy, as she was rolled out of her assembly hall in April 2017 and completed her first basin dive in January 2018. A detailed assessment of the situation was posted to the *Save the Royal Navy* website on 22 June 2019 at: https://www.savetheroyalnavy.org/hms-audacious-yet-to-begin-sea-trials-risking-further-decline-in-royal-navy-submarine-numbers/

10. See Sebastian Sprenger, 'Greek defense minister makes crowd-funding plea to afford new warships' posted to the *Defense News* site on 7 December 2018 at: https://www.defensenews.com/global/europe/2018/12/07/greek-defense-minister-makes-crowd-funding-plea-to-afford-new-warships/

11. Jaime Karremann's *marineschepen.nl* website remains an excellent source of information on the Royal Netherlands Navy, providing much additional information on the projects referenced in this section.

12. Devrim Yaylali's *Bosphorus Naval News* blog at: turkishnavy.net/ remains the premier English-language source for Turkish Navy developments.

13. See *Strategy of the Naval Forces of the Armed Forces of Ukraine 2035* (Odessa: The Naval Forces of the Armed Forces of Ukraine, 2019).

14. For further detail on the Portuguese Navy's current structure and future strategic ambitions see the author's 'Portugal's Naval Commitment', *European Security & Defence* – 7/2018 (Bonn: Mittler Report Verlag GmbH, 2018), pp.47–50.

15. The Accident Investigation Board Norway's preliminary marine accident report relating to the collision can be found at: https://www.aibn.no/Marine/Investigations/18-968. A final report will follow before the end of 2019. The author is particularly saddened over the loss of *Helge Ingstad*, which he was invited to tour at Navantia's Ferrol yard in July 2009 during *Seaforth World Naval Review's* formative stage.

16. An English-language summary of the cross-party Defence Commission's report – *Sweden's security policy and the development of its military defence* – can be found on the Government offices of Sweden website at: https://www.government. se/articles/2019/05/the-swedish-defence-commission-presents-its-white-book-on-swedens-security-policy-and-the-development-of-its-military-defence/

17. A good review of Russia's overall defence procurement strategy under GPV 2027 was provided by Tim Ripley in 'Briefing Russian defence modernisation: Putin's plans', *Jane's Defence Weekly* – 17 April 2019 (Coulsdon: IHS Jane's, 2019), pp.20–5.

18. For further detail, see Tim Ripley, 'Moscow's new drone mothership' submarine launched in Severodvinsk', *Jane's Defence Weekly* – 1 May 2019 (Coulsdon: IHS Jane's, 2019), p.4.

2.4A Fleet Review

Author:
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THE ROYAL NAVY Going Global

The Royal Navy[1] is entering the third decade of the twenty-first century in a more positive mood than it began the second. Whilst the ruthless cuts imposed on the Royal Navy (RN) by the Strategic Defence and Security Review in 2010[2] are still a bitter memory for many senior officers, many of the service's personnel have joined since then and have no recollection of that traumatic period.

After several difficult years which saw many warships spending too much time alongside in port, the Royal Navy has moved back to a higher operational tempo, with an emphasis on more global deployments – particularly 'East of Suez'. Indeed, the RN is now deploying ships to parts of the world that have not seen a sustained presence since the 1960s.

A NEW GLOBAL DEFENCE STRATEGY

In June 2016 the United Kingdom held a referendum which narrowly voted in favour of the country leaving the European Union, a process commonly called 'Brexit'. As of June 2019, the UK has not yet left the EU but the government has been assessing how to leverage the armed forces to increase Britain's influence on the world stage post this event. In December 2018 the Ministry of Defence (MOD) published the report *Mobilising, Modernising and Transforming Defence*.[3] Although light on detail, it highlighted the 'resurgence of state-based threats and competition' and specifically committed to increasing 'the points of presence of the Royal Navy around the world' with the Asia-Pacific region taking on renewed importance. Pre-empting the report, 2018 saw no fewer than five warships visit the Pacific Ocean and, in January 2019, the frigate *Montrose* became the first RN warship to visit New Zealand for 18 years.

In a speech on 11 February 2019, then Secretary of State for Defence, Gavin Williamson, said:

> [We are] increasing our global presence and building on our alliances. The UK is a global power with truly global interests… . we must be prepared to compete for our interests and our values far, far from home. Our global presence must be persistent … not fitful. We will also be using our string of global support facilities and military bases more strategically [to] project power both hard and soft. And, I believe that we need to [consider] what permanent presence we might need … to extend our global influence.[4]

A major step towards implementing this global presence is the forward deployment of RN vessels to regional bases (in some cases newly established) for three years or more. This avoids the cost and time wasted by ships transiting to and from the UK every six to nine months. Instead crews – in full or part – can be economically rotated by air transport.

The Royal Navy is entering the third decade of the twenty-first century in a more positive mood than it began the second, in part as a result of positive publicity surrounding the arrival of the new aircraft carrier *Queen Elizabeth*. This picture shows a F-35B strike fighter taking off from the carrier during Operation 'Westlant 18'. *(Crown Copyright 2018)*

The frigate *Montrose* forms the backdrop to one of the monolithic Moai statues of Easter Island during her 2018–19 transit of the Pacific. The armed forces – and the Royal Navy in particular – are seen as important in increasing the UK's global influence in the post-Brexit environment. *(Crown Copyright 2018)*

UK NAVAL FACILITIES IN FOREIGN WATERS

Overseas facilities that are currently readily available to the Royal Navy include:

Gibraltar: Home of the Gibraltar Squadron, consisting of two patrol boats, *Sabre* and *Scimitar*. An order for larger replacement vessels is expected by the end of 2019; these will help deter the regular intrusion of Spanish warships into British waters around the territory.

Bahrain: The Naval Support Facility HMS *Jufair* was commissioned on 5 April 2018 and is the headquarters of the UK Maritime Component Commander Persian Gulf (UKMCC) – a 1* Commodore. In mid-2019 the facility hosted the forward-deployed Type 23 class frigate *Montrose* (until 2022), the four ships of the 9th Mine Countermeasures Squadron (*Brocklesby*, *Shoreham*, *Ledbury* and *Blyth*), and the support ship RFA *Cardigan Bay.* Approximately 500 naval personnel are based in Bahrain.

Oman: In February 2019 the UK and Oman signed a defence agreement allowing the RN to use the new Arabian Sea port of Duqm, which – unlike HMS *Jufair* – can berth and dry dock the *Queen Elizabeth* class aircraft carriers.

Diego Garcia: The RN has access to the US Navy-operated Naval Support Facility Diego Garcia (barely known, but one of the largest naval facilities in the world), in the tropical British Indian Ocean Territory. Oddly the last RN ship to visit was the ice patrol ship *Protector* in 2015. Approximately thirty RN and RM personnel form Naval Party 1002 on the atoll, where they are responsible for policing and administration duties.

The minehunter *Ledbury* pictured with the *Marine Nationale*'s *L'Aigle* alongside the RFA *Cardigan Bay* in the course of exercise 'Artemis Trident 19' in the Persian Gulf. The two Royal Naval vessels are part of the forward-deployed naval contingent based at the *Jufair* naval support facility in Bahrain. *(US Navy)*

An image of the amphibious transport dock *Albion* entering the new port of Duqm in Oman at the start of Exercise 'Saif Sareea 3'. The facility is one of a number of growing overseas facilities that the Royal Navy can access. *(Crown Copyright 2018)*

Singapore: The British Defence Singapore Support Unit (BDSSU), including the eight personnel of Naval Party 1022, operates a naval repair and logistics support facility at Sembawang wharf. Although kept busy supporting allied navies, it has been underutilised by the RN for decades. However, 2018 saw an upsurge in RN activity and Singapore is seen as the likely location for a forward-deployed frigate to cover the Asia-Pacific region.

Caribbean and West Indies: The auxiliary *Mounts Bay* has been forward deployed to the region from June 2017 until 2020, using the American port of Charleston for maintenance periods. Montserrat and Guyana are being considered for the establishment of a small permanent British military base in the region.

Falkland Islands: The RN maintains a small permanent base at Mare Harbour, operated by Naval Party 2010. This is currently home for the offshore patrol vessel *Clyde*, soon to be replaced by the new *Forth*.[5]

From 2023, the Royal Navy intends to support its global presence through the periodic deployment of powerful task groups centred on a *Queen Elizabeth* class (QEC) aircraft carrier and her air group, plus escorts, submarines, amphibious ships and support ships. It could be difficult for the RN to maintain these task groups using only its own resources, and it is hoped that allies (NATO and non-NATO) will regularly contribute ships and aircraft. Initial indications are positive.

UK NAVAL BASES IN HOME WATERS

Since the mid-1990s, the RN has operated from three UK naval bases. The current allocation of major vessels is:

An aerial view of *Queen Elizabeth* alongside the Princess Royal Jetty at Portsmouth Naval Base in January 2018. Ships in the background include two Type 23 frigates and five out six Type 45 destroyers, the latter perhaps highlighting the low availability of the *Daring* class during 2018. *(Crown Copyright 2018)*

HM NAVAL BASE PORTSMOUTH

- 2 x *Queen Elizabeth* class aircraft carriers (from the end of 2019).
- 6 x Type 45 destroyers.
- 5 x Type 23 frigates.
- Mine Countermeasures Squadron 2 (MCM2) – 4 x 'Hunt' class MCMVs (two more in Gulf with MCM9).
- The Fishery Protection Squadron – 5 x offshore patrol vessels (including one forward deployed).

HM NAVAL BASE DEVONPORT

- 2 x *Albion* class amphibious transport docks (one in reserve).
- 8 x Type 23 frigates (including the forward-deployed *Montrose*).
- 3 x *Trafalgar* class attack submarines (to be withdrawn by 2022).
- The Survey Squadron – 3 x survey ships, the ice patrol ship *Protector* and one survey launch.

HM NAVAL BASE CLYDE

- 4 x *Vanguard* class strategic submarines.
- 3 x *Astute* class attack submarines (to increase to 7 in due course).
- Mine Countermeasures Squadron 1 (MCM1) – 5 x *Sandown* MCMVs (two more in Gulf with MCM9).

Protecting the Clyde-based *Vanguard* class strategic submarines is one of the Royal Navy's most important duties in home waters. 2019 marks the 50th anniversary since the Royal Navy took over responsibility for the UK's independent nuclear deterrent from the Royal Air Force. *(Michael Leek)*

Key operational capabilities that the RN maintains in UK waters include:

- Security duties related to the protection of the UK's nuclear deterrent.
- A Type 23 frigate on anti-submarine patrol duties, termed the 'Towed Array Patrol Ship'.
- Anti-submarine helicopters.
- A frigate or destroyer at high readiness, the 'Fleet Ready Escort'.
- A duty RFA tanker, usually tasked by Flag Officer Sea Training (FOST) at Devonport.
- Mine countermeasures capabilities.
- Constabulary patrols.

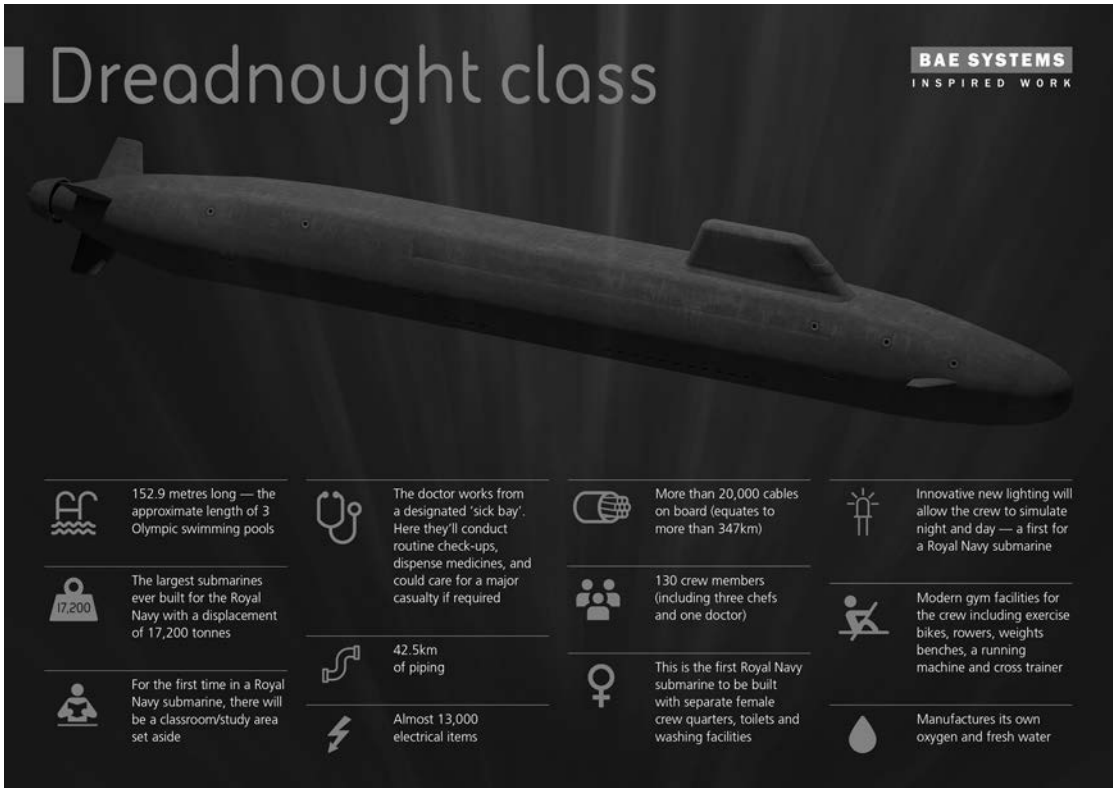
In November 2018 it was announced that as part of 'Brexit' preparations, three Batch 1 'River' class patrol vessels would be temporarily retained in service alongside their intended Batch 2 replacements to strengthen the protection of UK waters from illegal exploitation. The Fishery Protection Squadron has thus expanded from just two available patrol vessels in late 2017 to four in mid-2019 and could reach seven vessels by early 2021.[6] Also, several vessels of the Fishery Protection Squadron now 'forward-operate' from Portsmouth to other ports around the UK – *Tyne* to Newcastle, *Mersey* to Liverpool and *Severn* to Cardiff. This regional basing means less time in transit to patrol areas – and a quicker response to local problems.

THE SUBMARINE SERVICE

Strategic Submarines: 2019 marks the 50th anniversary since the Royal Navy took over responsibility for the UK's independent nuclear deterrent from the Royal Air Force (RAF). One of the four nuclear-powered ballistic missile submarines of the *Vanguard* class is always on patrol. Another is usually in refit, currently *Vanguard* herself. She is expected to re-join the fleet in 2020.

The *Vanguard*s entered service during the 1990s and will need replacing by the early 2030s. This has become the most expensive defence procurement ever undertaken by the UK. The £41bn (c.US$52bn) *Dreadnought* class ballistic missile submarine project is so important and expensive that the MOD is uniquely required to submit an annual report to Parliament on the project's progress.[7]

Spending is currently running at £1.2bn per annum, with an estimated 30,000 jobs dependent on the project. Some long lead-time items were ordered as early as 2011 and the first steel was officially cut for *Dreadnought* at the BAE Systems Submarines, Barrow-in-Furness shipyard in October 2016. However, large-scale assembly of her hull units will not begin until 2021. She is expected to conduct her first deterrent patrol in 2031, followed by *Valiant*, *Warspite* and *King George VI*. These submarines will be larger than the preceding *Vanguard* class – displacement will be 17,200 tons compared with c. 16,000 tons and length 153m as opposed to 150m. However, they will have only twelve rather than sixteen missile tubes and only eight of these will normally carry Trident D5 missiles. There has been no official indication as to


Dreadnought class
BAE SYSTEMS
INSPIRED WORK
152.9 metres long — the approximate length of 3 Olympic swimming pools
17,200
The largest submarines ever built for the Royal Navy with a displacement of 17,200 tonnes
For the first time in a Royal Navy submarine, there will be a classroom/study area set aside
The doctor works from a designated 'sick bay'. Here they'll conduct routine check-ups, dispense medicines, and could care for a major casualty if required
42.5km of piping
Almost 13,000 electrical items
More than 20,000 cables on board (equates to more than 347km)
130 crew members (including three chefs and one doctor)
This is the first Royal Navy submarine to be built with separate female crew quarters, toilets and washing facilities
Innovative new lighting will allow the crew to simulate night and day — a first for a Royal Navy submarine
Modern gym facilities for the crew including exercise bikes, rowers, weights benches, a running machine and cross trainer
Manufactures its own oxygen and fresh water

Although few illustrations of the new *Dreadnought* class strategic submarines have been published, this BAE Systems' infographic provides a broad overview of the design. (*BAE Systems)*

The *Trafalgar* class submarines have served the RN well for three decades, but all will be gone by 2022. This photo shows *Trenchant* surfaced at the North Pole on 20 April 2018, the first RN submarine to do this since *Tireless* in 2007. *(Crown Copyright 2018)*

whether the four 'surplus' tubes might be used for other purposes, for example to carry cruise missiles.

Attack Submarines: The Submarine Service has past the mid-point in its difficult transition from the *Trafalgar* class hunter-killer (attack) submarines, to the *Astute* class. In March 2018 the MOD confirmed the order for a seventh and final *Astute* class attack submarine. She will be named *Agincourt*. Her cancellation seemed likely at times during 2017 but this would have left BAE Systems Submarines with a gap in its workload. It was finally decided that the short-term savings were outweighed by the long-term risks and costs of recovering lost skills

Three *Astute*s are now in service and late 2019 should see the fourth boat – *Audacious* – commission. She should be followed by *Anson* in 2020, *Agamemnon* in 2022, and *Agincourt* in 2024. The inevitable corollary will be the disappearance of the *Trafalgar* class submarines. These have been the backbone of the RN's hunter-killer force for two decades, but their serviceability is now very poor. *Trenchant* celebrated the 30th anniversary of her commissioning in January 2019 and is expected to pay off within the next 12 months. The final two boats, *Talent* and *Triumph*, are expected to decommission in 2021 and 2022 after 31 years of service.

Unmanned Technology: In April 2019 the MoD sought solicitations from industry for trials of a large unmanned underwater vehicle (XLUUV). It is required to be deployable autonomously for periods of up to three months, with a range of up to 3,000 nautical miles. Intelligence-gathering will be a primary role. However, the budget for three years of research, design and testing is just £2.5m and it is not yet clear how attractive the programme will be to industrial partners.

AIRCRAFT CARRIERS

The RN's new aircraft carrier *Queen Elizabeth* visited the east coast of the USA between August and December 2018 for initial flight trials with the F-35B Lightning strike fighter. Among the highlights of 'Westlant 18' were:

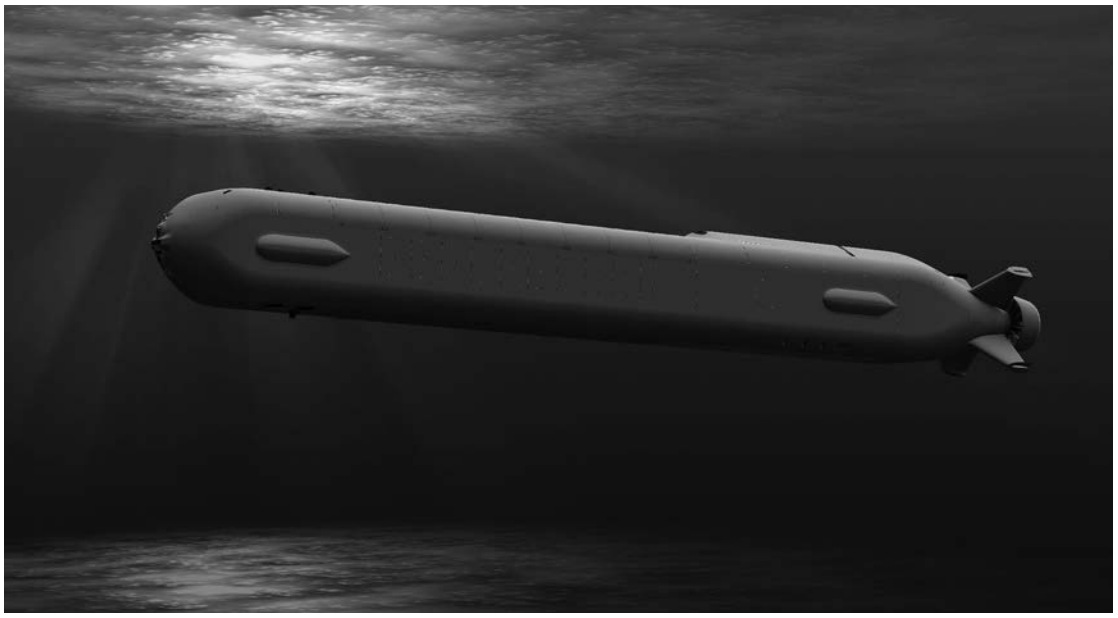
- **25 September 2018:** The first F-35B landing on the ship.
- **14 October 2018:** The first Shipborne Rolling Vertical Landing (SRVL) by an F-35B.
- **19 October 2018:** A visually spectacular entry into New York harbour.

Unfortunately, the deployment confirmed one problem – her crew was too small. It was originally hoped that she could be lean manned with a core crew of c. 680 personnel – similar to the retired *Invincible* class and far less than roughly equivalent ships in other navies, such as the US Navy's amphibious assault ship *America.* However, *Queen Elizabeth*'s then captain, Jerry Kyd, found that this was unworkable and he recommended a substantial increase. It is believed an uplift was approved in early 2019 – but not to the total requested.

Queen Elizabeth began 2019 in the course of a maintenance and capability insertion period (CIP) at Portsmouth Naval Base – this included a start on the installation of Phalanx close-in weapons systems for self-defence. In April she headed to the Babcock shipyard in Rosyth for a six-week docking period, her first since being floated out on 17 July 2014. The late summer will see *Queen Elizabeth* travel back to the USA's eastern coast for operational testing with F-35Bs of 617 Squadron and 17(R) Test and Evaluation Squadron embarked – 'Westlant 19'.

2020 should see *Queen Elizabeth* reaching her 'initial operational capability' (IOC), prior to commencing her first deployment in early 2021.[8] This will see her leading a Task Group to the Mediterranean, the Middle East and the Far East, possibly including a Freedom of Navigation Operation through the international waters of the South China Sea – waters that China now claims to have sovereignty over. *Queen Elizabeth* will embark a full-strength carrier air wing which is likely to include twelve F-35Bs of the RAF's 617 Squadron, a squadron of US Marine Corps F-35Bs, six to nine Merlin HM2s anti-submarine helicopters of 820 Naval Air Squadron, three to five Merlin Crowsnest airborne early warning helicopters from 849 NAS, and three Merlin HC4 transport helicopters of 845 NAS. A US Marine Corps MV-22 Osprey may be embarked for long-range carrier onboard delivery. It was announced in October 2018 that the Task Group would include a Dutch warship.

The other member of the QEC is *Prince of Wales*. She should start sea trials in November 2019 before



Boeing is building four 'Orca' extra-large unmanned undersea vehicles (XLUUV) for the US Navy. Lockheed Martin has also been undertaking development work on such systems, making the two companies leading contenders for a MOD contract to test a large autonomous underwater vehicle. *(Boeing)*

Queen Elizabeth entering New York City harbour on 19 October 2018. It is possible that she is amongst the biggest warships to have entered the port, as current US Navy carriers are too large to navigate these waters safely. *(Crown Copyright 2018)*

In December 2018 three consortia were awarded contracts to refine their proposals to meet the Royal Navy's requirement for Type 31e frigates. These illustrations show BAE Systems' 'Leander', Babcock's 'Arrowhead 140' and the South African Navy's MEKO A200 SAN light frigate *Amatola*, from which an Atlas Elektronik/ThyssenKrupp Marine Systems bid is likely to be derived. *(BAE Systems/Babcock International/South African Navy)*

moving to her homeport of Portsmouth. There has been some speculation that after commissioning in 2020 she might be placed in reserve for several years, thereafter alternating with *Queen Elizabeth* as the UK's in-service carrier. Alternatively, a shortage of UK-owned F-35Bs will mean that her first few years of service will focus on amphibious operations and the employment of a rotary-wing air group.

The QEC may yet gain a half-sister as BAE Systems is one of several companies that have been in discussions with India with respect to the Indian Navy's longstanding requirement for a third carrier. If a deal is eventually concluded, this would be based on the revised design with catapults and arresting gear that was cancelled by the UK in 2012.

SURFACE ESCORTS

The RN has nineteen escort vessels – six Type 45 air defence destroyers and thirteen Type 23 frigates. In recent years at least one of these has been laid up due to a lack of personnel, and another used as a harbour training ship. Allowing for other ships in refit or with serious defects, operational strength in 2018 and early 2019 was typically just seven units, with non-deployed units often having reduced crews and gapped billets.

The last escort commissioned for the Royal Navy was the destroyer *Duncan* in 2013; the next may be the Type 26 frigate *Glasgow* in 2025, after an unprecedented twelve-year gap. *Glasgow* was officially laid down on 20 July 2018 and is expected to be launched in 2021. She is the first of a planned eight 'City' class anti-submarine warfare frigates to be built by BAE Systems Maritime – Naval Ships at its shipyards on the Clyde. Whilst only three Batch 1 ships have so far been ordered, the names of all eight have been announced: *Glasgow*, *Cardiff*, *Belfast*, *Birmingham*, *Sheffield*, *Newcastle*, *Edinburgh* and *London*. *Glasgow* will not be fully operational until 2027, after 18 months of trials, followed by her sister-ships at about 18-month intervals.

Affordability was originally a key goal of the Type

26 design, but they evolved in to substantial (6,900 tons displacement, 150m long) and expensive warships – the first three are expected to cost £4.2bn (US$5.3bn), including some design and one-off costs. As a result, the MOD reduced its planned buy from thirteen to eight units in 2015. The National Shipbuilding Strategy published in 2017 assumed that the Type 26 was too expensive for export sales and placed great emphasis on developing a new low-cost frigate – the Type 31e – that would have greater export potential.[9] There was thus some surprise when in 2018 first Australia (nine units of the 'Hunter' class) and then Canada (fifteen units) decided to base their future surface combatants on the Type 26 design. However, these will be built in local shipyards, not in the UK.

The Type 31e project is a high priority for the RN. Despite life extension refits to the Type 23 frigates, they are scheduled to pay off at the rate of one a year from 2023 and the Type 26s will not arrive at the required pace. In October 2017 the MOD released a request for information (RFI) to industry that stated: 'The T31e will be a general purpose light frigate, providing an enduring and continuous worldwide maritime security presence in several forward operating areas, releasing other, more complex warships to their primary roles.'[10]

In December 2018 three consortia were each awarded a £5m contract to refine their proposals:

- **BAE Systems / Cammell Laird (Team Leander):** 'Leander', an enlarged version of the Omani 'Khareef' class corvette.
- **Babcock / Thales (Team 31):** 'Arrowhead 140' design, a derivative of the Danish *Iver Huitfeldt* class frigate.
- **Atlas Elektronik UK / ThyssenKrupp Marine Systems:** A UK variant of the MEKO A-200 class frigate.

The MOD has capped costs at £250m a vessel but the consortia have been insistent that the minimum characteristics cannot be met within this budget. As a compromise the amount of 'government furnished' equipment supplied to shipyards to fit out the vessels is under discussion. A contract for at least five Type 31e frigates is expected by December 2019; it is possible that a sixth Type 31e might be ordered as this would fulfil previous government promises to increase both the size of the RN and that of the escort force. The in-service date for the first Type 31e was initially set as 2023 but this looks increasingly optimistic.

The Type 45 destroyers are currently the subject of a £160m Power Improvement Project (PIP) to remedy serious defects with their propulsion systems. The project will replace the two existing diesel generators on each Type 45, add a third one, and upgrade the high voltage electrical systems. *Dauntless* is likely to be the lead ship to embark on the programme and should re-enter service with all the upgrades in 2021, followed by her sister-ships over the following few years.

MINE COUNTERMEASURES (MCM)

December 2017 saw a reduction in the RN's MCM force when the 'Hunt' class vessels *Atherstone* and *Quorn* were unexpectedly decommissioned rather than enter already-contracted refits. This leaves just nine MCM vessels in UK waters, including one being modernised. The primary role of the *Sandown*s of MCM1 is to protect nuclear submarines entering and leaving the HM Naval Base Clyde at Faslane, whilst the 'Hunts' of MCM2 are often utilised as patrol vessels. Both squadrons provide replacement crews for the four vessels of the Bahrain-based MCM9.

By 2020 all the 'Hunts' will be over 35 years old, with no direct replacements in sight. However, 2019 will see Thales deliver to the RN a demonstration system for remote/autonomous mine clearance trials as part of the Anglo-French Maritime Mine Counter Measures (MMCM) project. Separately, on 1 April 2019, the MOD announced a £75m order for two small autonomous minehunters to be operated by MCM9 in the Arabian Gulf.

AMPHIBIOUS OPERATIONS

In October/November 2018, UK and Omani armed forces participated in Exercise 'Saif Sareea 3' – hailed as the largest joint exercise by British forces since 'Saif Sareea II' in 2001. Unfortunately, only three amphibious warfare ships were available – *Albion*, *Lyme Bay* and *Cardigan Bay* – compared to six in 2001. Two 'Point' class sealift ships also provided a transport capability, but they needed a port to unload their cargo.

A Viking armoured personnel carrier from Commando Logistics Regiment training with Alpha Company from 40 Commando RM conducting drills in the Omani desert as part of 'Saif Sareea 3' in 2018. The exercise was hailed as the largest amphibious deployment by the Royal Navy since similar drills in 2001. *(Crown Copyright 2018)*

In late February 2019 Prevail Partners unveiled a proposal for a multirole vessel (MRV) that could meet the RN's requirement for a littoral strike ship. *(Prevail Partners)*

Three Sea King Mk7 ASaC aircraft pictured leaving their home at RNAS Culdrose for the last time on 26 September 2018 at the conclusion of the type's near 50 years of service with the Royal Navy. *(Crown Copyright 2018)*

The sale to Brazil in March 2018 of the landing platform helicopter (LPH) *Ocean* was a serious loss to the UK's amphibious capability. Officially the QEC have replaced *Ocean* but in practice they are far too valuable to be risked operating as an LPH near an enemy coastline. However, it is the intention that a deployed QEC will carry a Special Purpose Task Group (SPTG) of between 50 and 300 Royal Marines, supported by up to four Merlin HC4 transport helicopters. This will provide a modest military response force for on-shore operations that harks back to the days when battleships carried a RM detachment.

It was unexpectedly announced in February 2019 that two 'littoral strike ships' (LSS) would be ordered for the RN. These will have the ability to deploy ashore troops plus their equipment via helicopters and boats. The concept appears similar but smaller than the US Navy's expeditionary mobile base (ESB).[11] The LSSs will probably be conversions of existing ships, possibly two of the four 'Point' class sealift ships that the MoD has on charter from Foreland Shipping Ltd. It is intended that one LSS will be based 'East of Suez' to cover the Arabian Gulf, Indian Ocean, China Sea and Pacific Ocean; the second will be based in home waters to cover the Mediterranean Sea, Atlantic Ocean and Baltic.

The two *Albion* class landing platform docks (LPDs) were designed with a 25-year service life. They are now over 15 years old. However, no serious studies have begun on a replacement, possibly because their sale has frequently been proposed as a cost-saving measure.

Recent MOD statements have referred to a 'Future Commando Force'. This may differ from the Commando Forces 2030 strategy announced in April 2017, but no explanation has been provided. The last two years have seen the Royal Marines shrink in size by 531 trained personnel (from 6,833 in January 2017, to 6,302 in January 2019), a reduction of nine percent. This has had a negative impact on capabilities. Only 40 and 45 Commandos remain as full-strength infantry battalions; 42 Commando has been reduced to a source of detachments for SPTGs, augmentation and maritime security duties.

Whilst it includes only 200 Royal Marines, the Special Boat Service (SBS) provides Special Forces of the highest calibre. It operates an extensive collection of fast boats and submersibles; the chartered SD *Victoria* is used for training purposes whilst *Astute* class submarines can carry dry docks for operations. Maintaining the size and quality of the SBS from a decreasing pool of potential RM recruits will be a growing challenge.

FLEET AIR ARM (FAA)

The FAA is progressing its modernisation plans. Recent and imminent developments include:

- **25 May 2018:** Delivery of the first of twenty-five rebuilt and fully navalised ex-RAF Merlin Mk4/4A helicopters, which by 2023 will equip 845 and 846 Naval Air Squadrons of the Commando Helicopter Force in the medium lift and troop-carrying roles.
- **26 September 2018:** The FAA bid farewell to its last three Sea King helicopters; over 140 had served over a 49-year period.
- **24 October 2018:** The formation of 744 NAS; this will bring in to service the Merlin HM.2 heli-

copter fitted with the 'Crowsnest' radar and mission systems for airborne surveillance and control.

- **19 March 2019:** The first flight of a Merlin with Crowsnest.
- **31 December 2020:** Should see the UK's force of F-35B Lightning strike aircraft declare IOC (Maritime).

The most anticipated event is not due to occur until April 2023, when 809 NAS is scheduled to recommission equipped with twelve F-35Bs. After a 13-year break, the FAA will again have a front-line fast jet squadron. A decision is awaited as to whether the number of carrier-capable F-35Bs purchased by the UK will be limited to the forty-eight aircraft approved in 2015, enough to equip only two front-line squadrons. Subsequent purchases may instead be of the cheaper and more capable, but land-based only, F-35A variant.

Another major and expensive decision facing the MOD is how to replace the FAA's thirty Merlin HM2 helicopters. Their out-of-service date of 2029 means that planning and budgeting needs to start soon.

An important development in late 2020 will be the entry in to service with the RAF of the Boeing P-8A Poseidon Maritime Patrol Aircraft (MPA). This will end the UK's embarrassing decade-long dependence on allied MPAs to protect the country's waters from suspected intruding Russian submarines. It will also ease the burden on the FAA's overworked Merlin helicopters, which often undertake duties better suited to an MPA, in particular the safeguarding of *Vanguard* class submarines at the start and end of patrols.

The new 'Tide' class tanker *Tideforce* manoeuvring close to *Tidesurge,* running her rig to her sister-ship for a trial replenishment in May 2019. The recently-modernised *Fort Victoria* is close behind. *(Crown Copyright 2019)*

ROYAL FLEET AUXILIARY (RFA) SERVICE

Deployed RN warships used to be able to rely upon near ubiquitous replenishment and support services from RFA ships. However, recent years have seen a steady stream of RFA vessels being paid-off or laid up without replacement, resulting in warships having to make far more use of local ports for re-supply. Despite the RN's increasing focus on deployments East of Suez, between May 2018 and June 2019 no RFA supply ship was deployed to the Arabian Gulf, Indian Ocean or Asia-Pacific regions.

The RFA began to recover from a period of chronic underinvestment with the entry in to service between November 2017 and February 2019 of three new 'Tide' class tankers. They were built by Daewoo Shipbuilding and Marine Engineering (DSME) in Korea, but final fitting out was completed by A&P Group in the UK. The fourth and last unit is undergoing final trials and is expected to enter service by the autumn of 2019. With her arrival, it is possible that one or even both of the relatively young (completed 2003) 'Wave' class tankers will be declared as being surplus to requirements. Indeed, *Wave Ruler* is already laid-up in reserve, with Brazil considered a possible buyer.

In October 2018, the 25-year-old RFA *Fort Victoria* completed a major £44 million refit at Cammell Laird that should allow her to remain in service until the late 2020s. Major improvements included making her centreline fuel tanks compliant with MARPOL double-hull standards (the wing tanks are no longer used for fuel, significantly reducing capacity) and upgrading her four Clarke-Chapman replenishment rigs to allow her to supply the QEC with two-ton loads. She is now a key member of the UK carrier strike group, able to provide stores and munitions to the carrier, and fuel to her escorts. The RFA's other two solid support ships are *Fort Rosalie* and *Fort Austin*. They are now 40 years old and rotate in active service, with the former currently the operational unit. They are getting close to the end of their expected service life (2024) and there are no plans to replace their old pivot-arm Mk IA replenishment rigs with new ones compatible with the QEC.

Since May 2018 the MOD has been running a procurement process to replace all three 'Forts' with two or, maybe, three new ships of c. 40,000 tons displacement under the £1bn (US$1.2bn) Fleet Solid Support (FSS) ship programme. They will be equipped with a new fast and high-capacity Heavy Replenishment at Sea (HRAS) system that can transfer up to twenty-five 6-ton loads an hour to the QEC. HRAS will shorten replenishments and allow the transfer of heavy and bulky items such as replacement engines for F-35B fighters.

The FSS procurement is politically controversial as the ships have not been classified as warships and

A test firing of the new Sea Ceptor surface-to-air missile. The missile is being retrofitted to the existing Type 23 frigates and will equip the new Type 26 'City' class. *(Crown Copyright 2018)*

the construction programme has therefore been opened to foreign competition. In November 2018 four overseas shipyards were shortlisted for the contract: Italy's Fincantieri, South Korea's DSME, Japan's Marine United Corporation, and Spanish shipbuilder Navantia.[12] They are competing against the sole UK contender; a team led by Babcock and which includes BAE Systems, Cammell Laird and Rolls-Royce. A contract award is due in 2020, with the first ship to enter service in 2026.

The most versatile units in RFA service are the three 'Bay' class auxiliary dock landing ships or LSD(A)s. In recent years their duties have included acting as a 'mother ship' for mine warfare vessels, an in-harbour base for UK forces, leading humanitarian and disaster relief missions, and even filling in as a patrol ship. Regrettably a fourth ship was sold to Australia in 2011 when they were still seen as largely amphibious ships.

The only other RFA vessel is the casualty receiving and aviation training ship *Argus*. Completed in 1981 as a container ship, she entered RFA service in 1988 after conversion. All replacement plans have come to naught; simply extending her service life (currently to 2024 after a recently completed refit) keeps emerging as the lowest-cost option. Her eventual replacement might be a hospital ship partially funded from the UK's Official Development Assistance budget.

WEAPONS

The Royal Navy currently relies upon many old weapon systems that compare unfavourably with potential adversaries, but this situation is changing for the better.

The RN's Maritime Indirect Fire System (MIFS) requirement is being met by BAE Systems' 5in 62-calibre Mark 45 Naval Gun System. A US$245m order was placed for three operational mounts and a training system in 2016. The first will be delivered in 2020 for installation in the Type 26 frigate *Glasgow*. The Mark 45 will eventually supersede the 4.5in Mark 8 gun that has been fitted to most RN escorts since the early 1970s.

The Sea Ceptor anti-air missile system entered service in May 2018 and is replacing the 1970s vintage Sea Wolf missile system on the Type 23 frigates at the rate of two to three ships a year as part of their life-extension refits. The already upgraded *Argyll*, *Kent*, *Montrose*, *Northumberland* and *Westminster* will be joined by *Lancaster*, *Portland* and

A graphic of a ship-mounted Dragonfire 'Laser Directed Energy Weapon' engaging a target. Testing of a demonstrator system is planned for late 2019. *(MBDA UK)*

Richmond in 2019. Sea Ceptor will also be fitted to the Type 26 frigates.

The RN's primary surface-to-surface anti-ship missile (SSM) since the early 1990s has been the McDonnell Douglas (now Boeing) Harpoon. Its out-of-service date has been extended from 2018 to 2023, by which time the RN hopes to have acquired a modest number of a 'Next Generation Surface Ship Guided Weapon' (SSGW) at a cost of £100–200m. The Boeing Harpoon Block II+ and Lockheed Martin Long-Range Anti-Ship Missile (LRASM) are amongst leading contenders.[13]

The Spearfish heavyweight torpedo used by RN submarines entered service in 1992. It was designed for use against high-speed, deep-diving but noisy Soviet Union submarines and is less suitable for attacking modern ultra-quiet submarines. 2020 should see the entry in to service of an upgraded version of Spearfish which was ordered in 2014 at a cost of £270m.

The successful Sea Skua air-to-ship missile left service in 2017 after 35 years of use. Following substantial delays, a replacement Sea Venom missile – ordered from MBDA in 2014 at a cost of £500m (split with France) – should enter RN service in late 2021, where it will equip Wildcat helicopters. The Wildcat will also carry the Martlet Lightweight Multirole Missile; 1,000 missiles were ordered by the MOD from Thales UK at a cost of £93 million in October 2018 and deliveries will commence in 2020. The low-cost Martlet is intended for use against the small but fast craft used by drug smugglers and pirates.

The MOD is funding the development of directed energy weapons, aka lasers. In January 2017 a £30m contract was awarded to the Dragonfire consortium – led by MBDA – to demonstrate the potential of Laser Directed Energy Weapons. Live fire demonstrations should begin in late 2019.

One decision that has been outstanding for nearly a decade is whether to add an anti-ballistic missile capability to the PAAMS/Sea Viper air-defence system (including Aster missiles) fitted to the Type 45 destroyers. The UK is currently not partnering France and Italy in the pre-requisite Aster Block 1 NT (New Technology) programme.

The destroyer *Defender* shadowing a Russian Task Group including the new frigate *Admiral Gorshkov* through the North Sea and English Channel in March 2019. The Ministry of Defence has yet to decide whether to exploit the latent anti-ballistic missile capability provided by the PAAMS/Sea Viper surface-to-air missile system. *(Crown Copyright 2019)*

PERSONNEL

The biggest challenge facing the RN is a lack of trained personnel. Decades of defence cuts have led to the perception that the RN is an unattractive career choice. The 4,000 compulsory redundancies made between 2011 and 2014 remain a lingering PR disaster. At the start of 2019 the regular Royal Navy was 4.7 percent below its authorised trained strength. A report published in April 2018 revealed that the biggest shortfall in the Armed Forces was for engineering trades, with weapons engineers in the Royal Navy being in particularly short supply.[14]

Attempts since 2016 to increase the RN's strength have had modest results despite a well-regarded RN advertising campaign to attract new recruits. The full-time trained strength of the regular Royal Navy (only) was 22,667 officers and ratings on 1 January 2017, 22,746 on 1 January 2018, and 22,802 on 1 January 2019. Perhaps unsurprisingly, politicians prefer to quote 38,546 – this is the grand total of all personnel in the Naval Service on 1 January 2019, including Royal Marines, Royal Fleet Auxiliary (1,542), volunteer reservists (3,784) and untrained personnel.

A very difficult balancing act is having to be performed between bringing both QEC aircraft carriers into service, crewing additional OPVs, and minimising the number of frigates and destroyers in harbour due to a lack of personnel. One argument in favour for the sale of *Ocean* to Brazil was that her crew members were urgently needed elsewhere.

Given the continuing shortfall in personnel, it was puzzling when in an interview dated 14 March 2019, First Sea Lord Admiral Sir Philip Jones claimed: 'I'm pleased to say we have two crews for the two carriers [and] it's not at the expense of manning elsewhere in the fleet.'[15]

CONCLUDING REMARKS

After a traumatic decade, morale in the Royal Navy is finally improving. The commissioning of the aircraft carrier *Queen Elizabeth* has been an important factor. Perhaps more significant was the prevention in late 2017 of yet more cuts to the RN/RM when the then Defence Secretary, Gavin Williamson, managed to obtain extra funding from the Treasury and Prime Minister.

The renewal of the RN's presence in the Asia-Pacific region ('Far East' in old parlance) has unexpectedly become a priority. If current plans are realised, 2023 might see the forward deployment to Singapore of a RN Task Group. The reaction of China will show if this bold but expensive move by the UK will have a positive result.

Whilst an ambitious vision of a globally-deployed Royal Navy has been described by the United Kingdom's government, it is uncertain if the service really has the ships, personnel and money required to deliver this. At best, the RN is going be very thinly spread around the world at a time when Russian military activity around the UK has reached levels not seen since the Cold War.

Notes

1. Her Majesty's Naval Service consists of the Royal Navy, Royal Marines, Royal Fleet Auxiliary (RFA), Royal Naval Reserve, Royal Marines Reserve and the Naval Careers Service. This article sometimes uses the term 'Royal Navy' as a commonly accepted title for all of these.

2. See the author's analysis in 'United Kingdom: Defence Review Reshapes the Royal Navy', *Seaforth World Naval Review 2012* (Barnsley: Seaforth Publications, 2011) pp.97–107.

3. *Mobilising, Modernising and Transforming Defence* (London: Ministry of Defence, 2018), currently available at: www.gov.uk/government/speeches/modernising-defence-programme-update

4. A full transcript of the speech can be found at: www.gov.uk/government/speeches/defence-in-global-britain. On 2 May 2019 Gavin Williamson was controversially sacked by the UK's Prime Minister, Theresa May, and Penny Mordaunt appointed as the new Secretary of State for Defence. She is a Royal Naval Reservist; a status which may cause some interesting protocol challenges.

5. The Antarctic ice patrol ship *Protector* returned to its homeport of Devonport in April 2019 prior to undertaking a refit at Middlesbrough. She had reportedly travelled over 136,000 nautical miles since leaving the UK in 2015. She is due to return to the Falkland Islands before the end of the year.

6. These numbers exclude the offshore patrol vessel based in the Falkland Islands.

7. The latest report, *The United Kingdom*'s *Future Nuclear Deterrent: The 2018 Update to Parliament* (London: Ministry of Defence, 2018) is available at: data.parliament.uk/DepositedPapers/Files/DEP2018-1305/nuclear_Deterrent_Update_to_Parliament.pdf

8. The US Navy and US Marine Corps have greatly assisted the RN in the redevelopment of the carrier-enabled capabilities that were lost in 2010. For example, see news.usni.org/2018/09/28/first-f-35bs-operate-off-hms-queen-elizabeth-u-k-works-toward-native-carrier-strike-group. The Chinese PLAN's slower progress in developing its own carrier capabilities over the same period makes an interesting comparison, although they are starting from scratch in establishing their naval aviation capacity.

9. *National Shipbuilding Strategy: The Future of Naval Shipbuilding in the UK* (London: Ministry of Defence, 2017), accessible at: https://www.gov.uk/government/publications/national-shipbuilding-strategy

10. *Request For Information (RFI) to support Type 31e (T31e) Market* Testing (London: Ministry of Defence, 2018):assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/645149/T31e_RFI.pdf

11. In February 2019, Prevail Partners Ltd published a brochure for a concept LSS at prevail-partners.com/mrv/

12. Press reports in May 2019 indicated that Fincantieri and DSME have both withdrawn from the competition. For a summary of the arguments relating to the international competition, see *Briefing Paper Number 08351, Fleet Solid Support Ships* (London: House of Commons Library, 6 July 2018), available at: www.parliament.uk/commons-library

13. In the longer term, the UK intends to develop a new generation of surface strike missiles with France. The Anglo-French parliamentary report *Future Anti-Ship Missile Systems: Joint inquiry with the Assemblée nationale*'s *Standing Committee on National Defence and the Armed Forces* (London: House of Commons, 2018) provides a lot of interesting information on the current RN position and future intentions. This is accessible via www.publications.parliament.uk

14. *Ensuring sufficient skilled military personnel* (London: National Audit Office, 2018). Accessible via www.nao.org.uk

15. The Admiral was giving an interview to *The News*, Portsmouth. In a contrary view, on 13 May 2019 retired General John Houghton, former Chief of the Defence Staff, told the National Security Strategy committee that he was concerned about the 'critical state' of manning in the Royal Navy.

2.4B Fleet Review

Author:
Dieter Stockfisch

THE GERMAN NAVY

The fleet is growing

Deployable worldwide, the German Navy (*Deutsche Marine*) is a highly flexible force that benefits from being one of the most advanced fleets operating today. This applies not only to its innovative management and command and control systems but, particularly, to the technology it uses. The Germany Navy's (GN's) primary tasks are national and collective defence. However, international crisis management, conflict prevention and the maintenance of maritime security in collaboration with Germany's international partners are also important roles. The GN is firmly integrated into the system of international alliances. As such, commitments made to the North Atlantic Treaty Organisation (NATO), the European Union (EU) and the United Nations (UN) have a high priority.[1] Above all, the GN is deeply embedded in the NATO alliance.

The German Navy's F123 class frigate *Bayern* pictured refuelling from the tanker *Spessart* in the Indian Ocean during the summer of 2016. The German Navy has been heavily focused towards international crisis management and conflict prevention since the end of the Cold War but a changed political backdrop means that the ability to conduct combat operations as part of national and collective defence is now assuming renewed importance. *(EU Operation Atalanta)*

MULTINATIONAL COOPERATION

The significance of the GN's collaborative focus is reflected in the fact that the majority of its regular training events, exercises and operational deployments are international in nature. Over the years, the GN has developed a broad range of cooperative activity with other NATO navies. For example, surface-warfare training and exercises are conducted with the British Royal Navy, whilst German surface units have integrated into US Navy carrier strike groups and France's carrier group in the course of deployments to the Middle East. Underneath the waves, developing cooperation between Germany and Poland provides another good example of multinational collaboration. This is evidenced by

The Royal Norwegian Navy minehunter *Måløy* pictured alongside the German tender *Elbe* during a NATO exercise in October 2016. Multinational collaboration through NATO and other partnerships forms an important of the Germany Navy's strategy. *(Jakob Østheim/Norwegian Armed Forces)*

Poland joining Germany´s submarine operating authority in 2016.

In 2015, the GN initiated the annual Baltic Commanders' Conference. This brings together senior naval leaders from the Baltic region to share perspectives and generate ideas for further cooperation.[2] The forum is a particularly useful mechanism for Finland and Sweden – both non-NATO partners – to deepen their maritime defence relationships, primarily with the GN. Meanwhile, close ties to the Royal Netherlands Navy in the area of amphibious warfare provide an avenue by which GN forces are able to conduct amphibious deployments. Access has been provided to the Dutch joint support ship *Karel Doorman* as part of a broader agreement that will see the German Marine Infantry (Sea Battalion) integrated into the Royal Netherlands Marine Corps.

The GN also operates a number of development and testing facilities as part of an international, inter-service network. One of the most significant of these is NATO's Centre of Excellence for Operations in Confined and Shallow Waters (COE CSW), which is affiliated with Allied Command Transformation. Based in Kiel, COE CSW develops concepts and doctrine for operations in the littoral environment. It also provides subject matter expertise for related NATO maritime training and exercises.

Although multinational cooperation has been standard practice for decades, the GN will undoubtedly have to intensify this approach in future given the finite resources available to meet an era of new challenges. This is likely to be particularly important at the European level in the context of a permanent EU collaborative military framework.

CURRENT CAPABILITIES AND FLEET COMPOSITION

The GN contracted significantly in the wake of the

The F125 *Baden-Württemberg* class frigates exemplify the German Navy's post-Cold War reorientation away from warfighting towards lower-intensity operations. Seen here on trials in 2016, the lead member of the class was delivered in April 2019 following a lengthy delay needed to rectify construction defects. *(German Navy)*

Table 2.4B.1: GERMAN NAVY – PRINCIPAL UNITS AS AT MID-2019

TYPE	CLASS	NO.	YEAR[1]	TONNAGE	DIMENSIONS	SPEED	PRINCIPAL ARMAMENT
Submarines (6)							
Submarine (SSK)	Type 212A	6	2005	1,800 tons dived	56m x 7m x 6m	DE + AIP 20 knots	6 x 533mm TT for torpedoes and mines
The last two Type 212A were built to a revised design and are slightly longer. The construction of two additional Type 212CD variants of the Type 212A design is planned.							
Fleet Escorts (10+3)[2]							
Frigate (FFG)	F122 **BREMEN**	2	1982	3,700 tons	131m x 15m x 6m	CODOG 30 knots	1 x octuple SAM, 2 x quad SSM, 2 x RAM, 1 x 76mm, 4 x TT, 2 x helo
Frigate (FFG)	F123 **BRANDENBURG**	4	1994	4,900 tons	139m x 17m x 6m	CODOG 29 knots	16 x VLS SAM, 2 x quad SSM, 2 x RAM, 1 x 76mm, 4 x TT, 2 x helo
Frigate (FFG)	F124 **SACHSEN**	3	2003	5,800 tons	143m x 17m x 6m	CODAG 29 knots	32 x VLS SAM, 2 x quad SSM, 2 x RAM, 1 x 76mm, 6 x TT, 2 x helo
Frigate (FFG)	F125 **BADEN-W'BERG**	1+3[3]	2019	7,300 tons	150m x 19m x 5m	CODLAG 26 knots	2 x quad SSM, 2 x RAM, 1 x 127mm gun, 2 x helo
A new MKS-180 design, sometimes referred to as the F126 class, is scheduled to enter production shortly for delivery in the second half of the 2020s.							
Patrol Escorts (5+5)							
Corvette (FSG)	K130 **BRAUNSCHWEIG**	5+5	2008	1,900 tons	89m x 13m x 5m	Diesel 26 knots	2 x twin SSM, 2 x RAM, 1 x 76mm, 1 x helo (platform only), mines
The five units of the second batch currently on order are being built to a slightly revised design.							
Mine Countermeasures Vessels (12)							
MCMV	Type 352 **ENSDORF**	2	1990	650 tons	54m x 9m x 3m	Diesel 18 knots	Light weapons, minelaying capability
MCMV	Type 332 **FRANKENTHAL**	10	1992	650 tons	54m x 9m x 3m	Diesel 18 knots	Light weapons, minelaying capability
A preliminary requirement for 11 replacement mine countermeasures vessels has been identified. It is intended that they will enter service in the second half of the 2020s.							
Support Vessels & Auxiliaries (14)							
Combat Support (AOR)	Type 702 **BERLIN**	3	2001	21,000 tons	174m x 24m x 7m	Diesel 20 knots	Light weapons, 2 x helo
Tanker (AOL)	Type 704 **RHÖN**	2	1977	14,200 tons	130m x 19m x 8m	Diesel 16 knots	Fitted for light weapons
Tender	Type 404 **ELBE**	6	1993	3,200 tons	101m x 15m x 4m	Diesel 15 knots	Light weapons, 1 x helo (platform only)
Intelligence Ship (AG)	Type 423 **OSTE**	3	1988	3,200 tons	84m x 15m x 4m	Diesel 20 knots	Not armed
There is a requirement to replace the two Type 704 tankers within the next decade. Other ships in German Navy service include three sea-going tugs, two pollution control vessels, a trials vessel and the sail training ship *Gorch Fock*. The fleet is supported by various harbour tugs and other yard craft.							

Notes:

1. Date relates to the date the first ship of the class entered service with the German Navy. In some cases, these ships are now retired.
2. Second number refers to ships of the type/class currently under construction or on firm order
3. The first F-125 *Baden-Württemberg* class frigate was delivered in April 2019 prior to commissioning on 17 June 2019. Three others will follow, replacing the remaining F122 class ships.

Cold War. The number of warships fell from around 160 in 1990 to a little under 50 today while personnel strength was reduced from 36,500 to 16,200 over the same period. Nevertheless, the GN has introduced a number of cutting-edge technologies and class-leading units during this timescale, perhaps most notably the Type 212A AIP-equipped submarines.

The post-Cold War period also saw a re-orientation from high-intensity warfighting towards crisis management in terms of both training and warship procurement. The latter is perhaps best exemplified by the imminent arrival of the new F125 *Baden-Württemberg* class frigates, which are optimised for low-intensity and expeditionary operations. In spite of this, German maritime forces are by far the largest in the Baltic region and the current fleet has retained a range of capabilities that are relevant to contemporary challenges. These include sea-based air defence, mine countermeasures (MCM) capabilities, and anti-submarine warfare (ASW).

To ensure that the GN is capable of accomplishing the tasks laid down in the Federal Government´s 2016 White Paper on *German Security Policy and the Future of the Bundeswehr*, maintenance of a 'balanced fleet' is required.[3] Ships, aircraft, the Sea Battalion and Special Forces must be able to conduct war at sea in three dimensions: above water, under water and in the air. Each and every naval asset is focused on performing at least one task. In maritime operations all these 'specialists' mesh like wheels in a clock. It takes just one cog to be missing for the whole system to fail. The GN therefore needs every one of the naval assets described in this chapter if it is to be capable of accomplishing its mission reliably and ensuring the safety of the German people.

Current major German fleet units are listed in Table 2.4B.1, with main warship types summarised further below.

FRIGATES

German frigates are optimised for a range of tasks. These include the exercise of command and control over task forces at sea and ashore, sea surveillance, ASW, the engagement of surface units (ASuW) and anti-air warfare (AAW). All the frigates have sophisticated electronic equipment and are therefore also

The four F123 *Brandenburg* class frigates were commissioned during the 1990s and are optimised for anti-submarine warfare. This is *Mecklenburg Vorpommern* in 2010. *(German Navy)*

suitable for use as command ships. Three types are in operational use at present:

F124 *Sachsen* Class: Commissioned early in the current Millennium, these three frigates are still the fleet's most advanced surface units and are primarily designed for AAW. They can protect military forces, civilian populations or economic centres. They are equipped with an active phased-array radar that can direct both SM-2 and Evolved Sea Sparrow surface-to-air missiles. Now in service for over a decade, they are regarded as providing a mature capability.

F123 *Brandenburg* Class: Dating from the mid-1990s, these four frigates are primarily used as command ships and are optimised for ASW.

F122 *Bremen* Class: The two survivors of an original eight-strong class are also primarily intended for ASW. Derived from the Dutch *Kortenaer* or 'Standard' design, the class originally entered service from the early 1980s onwards.

On 30 April 2019, the GN took delivery of the first of four new F125 *Baden-Württemberg* class frigates, which are primarily designed for protracted low-intensity operations such as crisis prevention and anti-terrorism.[4] The frigate's 127mm gun and surface-to-surface missiles also enables it to engage other warships and targets ashore, whilst ASW operations can be conducted by up to two embarked helicopters. Her commissioning into the operational fleet in mid-2019 marks a significant boost for the GN's modernisation programme. Notably, the new ships incorporate technology and equipment that is so robust and requires such little maintenance that they can be used continuously in operations for up to two years. Eight crews will be provided for the four frigates, with personnel rotating between ships and no crew deployed for more than four months at a time. The operating concept will be rounded off by shifting significant training elements to simulators

The K130 *Braunschweig* class corvettes – *Magdeburg* is seen here – are designed to be suitable for global deployment in littoral waters. *(German Navy)*

The shallow waters of the Baltic are particularly susceptible to mine warfare and the German Navy maintains the region's largest minesweeping force. This is the *Frankenthal* class MCMV *Sulzbach-Rosenberg* alongside at her base port of Kiel in February 2018. *(German Navy)*

ashore. The end result should be to allow half of the F125 class to be used continuously on operations; currently no more than a third of the ships in other frigate classes are typically available for operational use. Needless to say, this new concept is being kept under close watch both by the GN and NATO partner fleets.

CORVETTES

Commissioned from 2008 onwards, the K130 *Braunschweig* class corvettes are relatively new types of ships for the GN. Ocean-going vessels of good endurance, the class is intended for global deployment in littoral waters. Armed with long-range RBS15 Mk3 sea-skimming missiles, the corvettes are capable of engaging ship and shore targets with a high degree of precision and are well suited for supporting joint or multinational operations from the sea. All of an initial batch of five are now operational and they are to be equipped with the Skeldar V-200 unmanned aerial vehicle (UAV) in the course of 2019.[5]

MINE COUNTERMEASURES VESSELS

The GN currently operates twelve mine countermeasures vessels of the *Frankenthal* and *Ensdorf* classes, which also have a minelaying capability. The crews of some of these ships include clearance divers capable of identifying and disposing of sea mines. Important equipment includes the *Seefuchs* (Seafox) drone – a one-shot mine disposal weapon – and the *Seehund* (Seal) remote-controlled sweeping drone, which allow mine disposal to be conducted reliably and safely at distance from the controlling vessel.

SUBMARINES

The GN's six Type 212A submarines arguably provide the navy with the best conventional submarine capability in the world. As a result of the use of air-independent fuel cells, these submarines can operate in a similar fashion to nuclear-powered submarines in so far as they can remain fully submerged for several weeks at a time. The submarine flotilla's tasks include ASuW operations, recon-

The German Navy's Type 212A class AIP-equipped submarine *U-34* photographed at sea during the course of a NATO exercise in August 2016. These submarines are widely regarded as amongst the best conventional submarines in the world. *(German Navy)*

The three *Berlin* class combat support ships – *Frankfurt am Main* is seen here – are the German Navy's largest warships, providing the fleet with the ability to operate independently on a global basis. *(German Navy)*

naissance and intelligence collection. They can also support covert operations, for example by embarking and deploying Special Forces.[6]

AUXILIARIES AND SPECIAL TASK UNITS

The GN's wide range of auxiliary ships encompasses supply vessels, tenders, oilers, tugs, utility landing craft, oil recovery ships and salvage tugs. This fleet extends the endurance of operational units at sea by supplying fuel, water, food, spare parts and ammunition. It also provides maintenance, training and medical support and helps clean up oil spills at sea.

Prominent amongst the GN's auxiliaries are the three AOR type *Berlin* class combat support ships. These vessels, the largest in the GN, can also be used as hubs for commanding and coordinating joint army, air force and navy operations. Moreover, the installation of containerised medical facilities can also transform them into floating hospitals which deliver the same standard of care to personnel deployed on operations as would be provided at a German district hospital.

A different type of capability is provided by the three *Oste* class intelligence vessels. Equipped with a spectrum of secret information gathering equipment, they are regarded as highly-efficient early warning, communications and reconnaissance ships. They are capable of global deployment and operate both independently or in conjunction with other German and allied intelligence assets.

The most distinctive vessel in the GN is arguably *Gorch Fock*, a c. 2,000-ton sail training ship. Since 1958, more than 14,500 naval cadets have been trained on the ship.

Alster, one of three *Este* class intelligence-gathering vessels, provides an efficient early-warning and communications capability. *(German Navy)*

NAVAL AVIATION

The GN's naval aviation component *(Marineflieger)* comprises around fifty aircraft. It operates both fixed-wing and rotary types, the former all being land-based.

There are two types of fixed-wing aircraft. The P-3C Orion is a four-engine propeller aircraft that is used as a long-range maritime patrol aircraft (MPA). Principal missions are sea surveillance, ASW and the support of operations ashore. Eight are currently in service. The Do 228 LM is a modern multi-role

The traditional sail training ship *Gorch Fock* commissioned in 1958, replacing a ship of the same name and similar design surrendered to the Soviet Union as war reparations. More than 14,500 cadets have been trained on the ship since then. *(German Navy)*

A German Navy P-3C Orion MPA returning from the anti-piracy Operation 'Atalanta' in the Indian Ocean, pictured in Djibouti, East Africa. *(3rd Naval Air Wing)*

Mine clearance divers in action during a mine countermeasures exercise in the Baltic Sea. The clearance diving company forms an important part of the German Navy's Sea Battalion. *(German Navy)*

aircraft with highly sensitive sensors for monitoring the sea surface. There are two aircraft and their main use is to detect maritime pollution.

There are also two main types of front-line rotorcraft. The Sea Lynx Mk 88A is a shipboard helicopter used mainly on frigates. It is equipped and armed for use in sea surveillance, ASW and ASuW roles. It is also used for transport purposes and in the Search and Rescue (SAR) role within a maritime task force. The Sea King Mk 41 is a medium transport helicopter that is used in a SAR role and as an armed shipboard helicopter on combat support ships. It can be used in support of Special Forces' missions in crisis regions, to transport supplies and people in emergency or disaster relief operations and to evacuate people in danger. Twenty-two Sea Lynx and twenty-one Sea King helicopters are currently in service.

THE SEA BATTALION AND NAVAL SPECIAL FORCES

The c. 800-strong Sea Battalion comprises marine infantry (shore force protection), clearance diving, boarding team and reconnaissance companies. The shore force protection company secures ports and beaches. The clearance divers clear explosive ordnance on land and in water. The reconnaissance company uses its unmanned underwater and aerial vehicles to search sectors of the coast and deploys its snipers to conduct reconnaissance. The boarding or naval security company searches suspicious ships and protects vessels against attack.

The Naval Special Forces Command, the oldest Special Forces unit in the German Armed Forces (*Bundeswehr*), is composed of combat swimmers. They are employed for special missions in support of sea, air and land operations. Key tasks are fighting international terrorism, reconnoitring ports and shores, collecting information and supporting armed evacuation operations. Others include protecting friendly ships and naval installations at home and abroad and participating in non-combatant evacuation operations.

COMMAND AND ORGANISATIONAL STRUCTURE

A simplified overview of the GN's structure and principal bases is provided by Diagram 2.4B.2. The GN's Naval Command is headquartered in Rostock (once part of the German Democratic Republic) on the Baltic. The head of the GN – the Inspector of

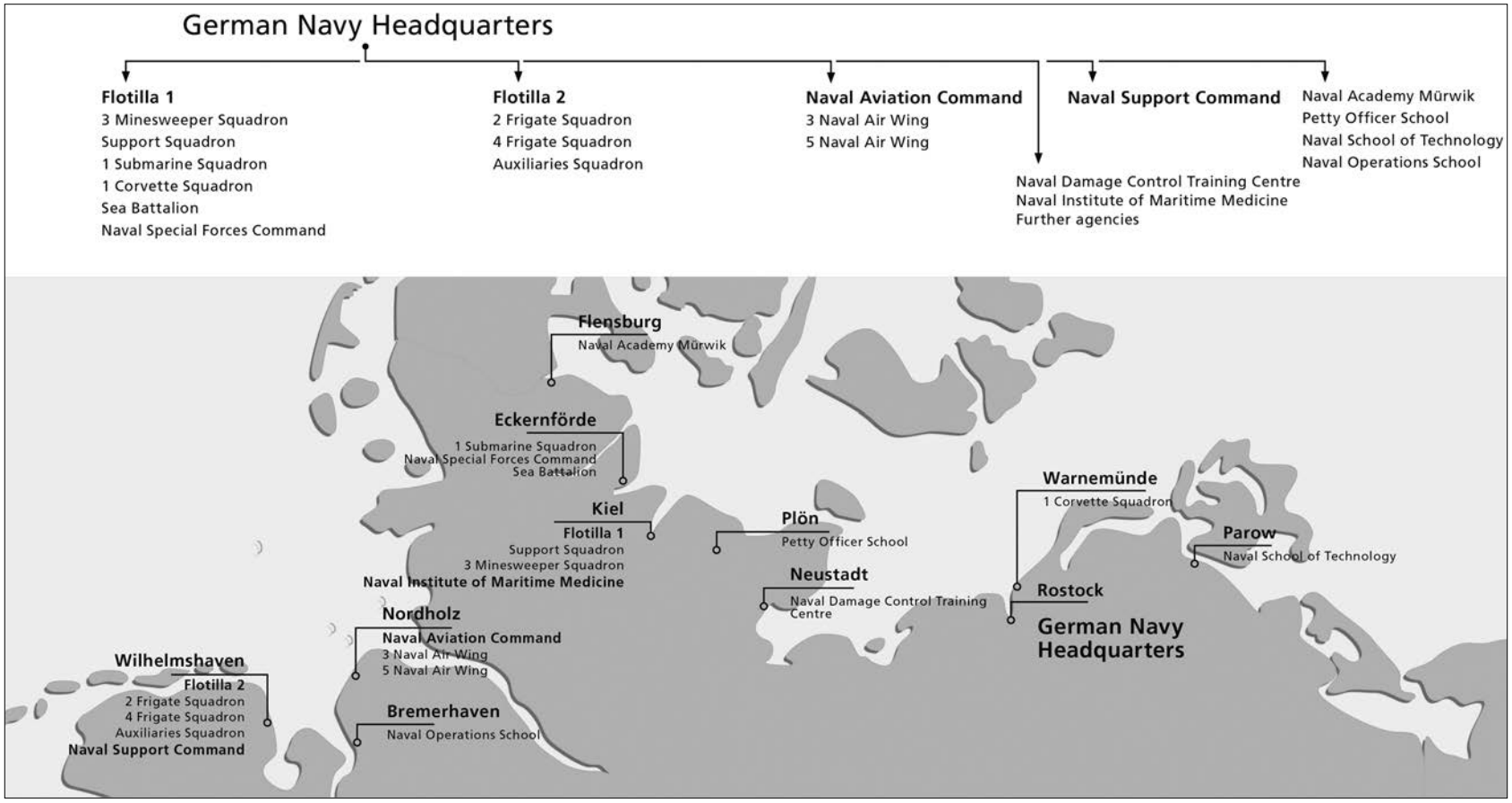


Diagram 2.4B.2: GERMAN NAVY – SIMPLIFIED STRUCTURE & MAIN BASES

German Navy Press and Information Centre/iStockphoto

the Navy – is supported by a Deputy Inspector and by a Chief of Staff. Structurally, the command is divided into five departments responsible for (1) operations, including the sea-going flotillas and naval aviation, (2) planning, (3) personnel, training and organisation, (4) operations support, and (5) the medical service. Since October 2014, the Inspector of the Navy has been Vice Admiral Andreas Krause.

The renewed focus on national and collective defence is having a marked impact at GN headquarters, where a new navy operations organisation – DEU MARFOR – is currently being established. This will consist of a national staff that can be reinforced by allied navy personnel and built up to form a multinational planning and executive (command) group. It will be capable of planning and executing all kinds of maritime operations on a global basis, although there is likely to be a strong emphasis on

The German Navy's assets in the Baltic are under the command of the First Flotilla headquartered at Kiel. This June 2016 photograph shows the tenders *Elbe* and *Donau* alongside at the naval base. *(German Navy)*

The F124 class air-defence frigate *Hessen* pictured operating with the US Navy in the Mediterranean in April 2018. Along with the rest of the German Navy's frigates, she forms part of the Second Flotilla and is based at Wilhelmshaven, where she is a member of the 2nd Frigate Squadron. The three F124 class vessels are to be upgraded as part of the navy's modernisation plans. *(US Navy)*

Baltic requirements. Indeed, DEU MARFOR is seen as the first step in developing and building a larger, international Baltic Maritime Component Command (BMCC). Also based at Naval Command in Rostock, this will have a command architecture fully compliant with NATO standards and is expected to reach initial operating capability around 2023.

Operationally, the GN's assets in the Baltic Region are under the command of the First Flotilla, which is based in Kiel. Kiel is home to the 3rd Minesweeper Squadron and the Support Squadron, to which all the flotilla's supply vessels are assigned. The 1st Submarine Squadron, the Sea Battalion and the Naval Special Forces Command are based in Eckernförde whilst the 1st Corvette Squadron is in Rostock/Warnemünde. As already noted, Kiel is also the location for COE CSW.

The Second Flotilla, which is more focused towards operations in the North Sea and beyond, is based at Wilhelmshaven. It comprises the 2nd Frigate Squadron, the 4th Frigate Squadron and an Auxiliary Squadron of supply and support ships.

The GN´s airborne weapon systems are based at the Naval Aviation Command in Nordholz/Cuxhaven. This command consists of 3rd Naval Air Wing, with long-range MPAs and oil surveillance aircraft, and 5th Naval Air Wing operating ship-based helicopters and – in the future – naval drones.

Away from the front-line forces, the Naval Support Command in Wilhelmshaven is responsible for managing the operation and service support of all naval units. Future Navy officers are trained at the Naval Academy Mürwik at the traditional base of Flensburg. Further training institutions are the Petty Officer School in Plön, the Naval School of Technology in Parow and the Naval Operations School in Bremerhaven.

MODERNISATION AND PROCUREMENT PLANS

The years of GN shrinkage are now over and the fleet looks set to grow again. Indeed, the fleet is in the process of arguably its most comprehensive modernisation programme since first establishment, with a wide range of new, highly-capable warships and aircraft either in the course of delivery or planned. Over the next decade, the GN can expect to receive between one or two new vessels each year whilst also renewing its helicopter component. By 2030, it is anticipated the fleet structure summarised in Diagram 2.4B.3 will have been achieved. Modernisation will also extend to existing units. For example, the F123 class frigates will receive state-of-the art software improvements whilst the F124 class is to be equipped with an upgraded air-defence radar system. The latter will enable these ships to locate ballistic missiles approaching from space and to transmit target data in real time to other ships, which will then engage the ballistic missiles. Alongside the planned upgrades to equipment will be a series of steps to make the naval service more attractive for its personnel.

The most important planned procurement programme is probably that for the MKS 180 multi-role combat ship, a new type of warship that will strengthen the GN´s national and collective defence capabilities. The MKS 180 constitutes a continuation of the innovative concepts that the Navy implemented with the F125 class frigates but is designed for high-intensity naval warfare and will be equipped accordingly. As well as being suitable for ASW, they should be able to engage surface and shore targets, carry additional personnel or materiel and command multinational task groups. An order for six vessels is

The K130 class corvette *Erfurt* seen in Plymouth Sound in September 2017 whist undergoing training with the Royal Navy's FOST organisation. She is based at Rostock/Warnemünde with the other ships of the 1st Corvette Squadron. A second batch of five K130 class vessels is currently under construction, doubling the class's size. *(German Navy)*

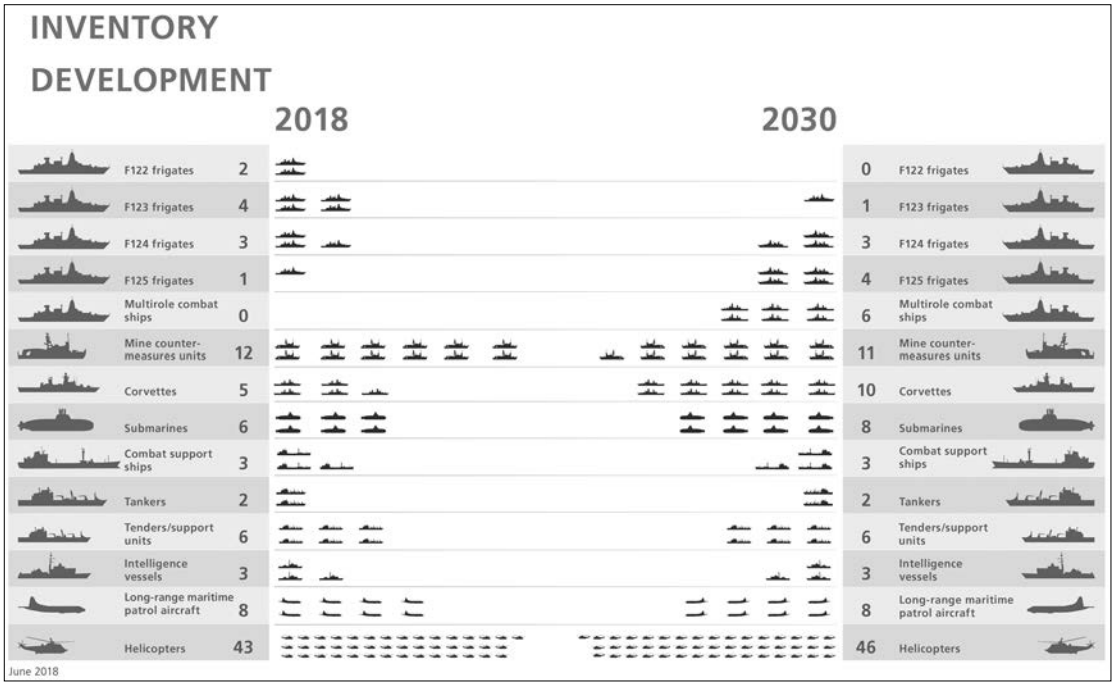


Diagram 2.4B.3: GERMAN NAVY COMPOSITION – 2018 TO 2030 *German Navy Press and Information Centre/iStockphoto*

Germany has ordered eighteen new NH90 helicopters – designated the Sea Lion in German Navy service – to replace the navy's aging Sea Kings. The first is expected to be delivered towards the end of 2019. *(Eurocopter)*

planned, with entry into service scheduled for the latter half of the next decade.

The MKS 180 ships will be preceded by a second batch of five K130 *Braunschweig* class corvettes. Ordered under a contract reportedly valued at nearly €2.5bn (US$2.8bn) in September 2017, all these five ships are scheduled for delivery by 2026. Steel for the first – to be named *Köln* – was cut in February 2019 and was followed by a formal keel-laying ceremony on 25 April. She will be followed by *Emden*, *Karlsruhe*, *Augsburg* and *Lübeck.*

Other upcoming projects include an additional two Type 212 series submarines – the Type 212CD class – to be procured as part of the GN's unique strategic partnership with the Royal Norwegian Navy. The mine countermeasures squadron will also be renewed in the second half of the coming decade, with a requirement for eleven vessels identified. The next generation mine-hunting capability will, in part, be based on unmanned and autonomous systems that are currently being tested in the Baltic. There is also a need for new support and training vessels, as well as for small fighting vessels for the Special Forces.

Modernisation of naval aviation will include life extensions for the existing P-3C Orions with new wings and onboard electronics. 2019 will see the start of the replacement of the Sea King Mk 41 helicopters – now over 40 years old – with the new Sea Lion variant of the NH90. A total of eighteen will eventually join the fleet. A competition is also imminent for the replacement of the existing Sea Lynx Mk 88 helicopters with new rotorcraft.

BACK TO THE NORTH

The GN is currently undergoing a rebalancing towards the Baltic and the North Atlantic, after more than two decades of focussing on crisis management and maritime security operations in the Mediterranean and the Indian Ocean. This presents a real opportunity to strengthen collective defence and deterrence in Northern Europe. The GN is in a particularly good position to help fill some of the command and control capability gaps found in the region where many other maritime forces are highly sophisticated, but relatively small in size and capacity.

In the Baltic region, NATO faces real challenges to the Alliance´s ability to reinforce the Baltic States and to operate at and from the sea during a crisis. This is primarily a result of Russia´s powerful anti-

The re-emergence of Russian naval power is resulting in the German Navy currently undergoing a rebalancing towards the Baltic and the North Atlantic. The Type 212A submarines are particularly potent assets in this environment: this is *U-31* in company with the salvage tug and support vessel *Fehmarn* in October 2018. *(German Navy)*

access/area-denial (A2/AD) network that is currently being developed in the Kaliningrad enclave and which encompasses sophisticated and long-range air defence systems, anti-ship missiles and ballistic missiles. The introduction of new Russian aviation assets also means that Russian air power can conduct strikes against both land targets and shipping at sea in the broader Baltic region. In addition, Russia has recently deployed warships capable of launching Kalibr land attack cruise missiles to the Baltic Sea.

The challenges posed by a more assertive Russia and its resurgent Northern Fleet based around the Kola Peninsula are somewhat different. Notably, the Northern Fleet is renewing its power-projection capabilities with the arrival of new and highly sophisticated submarines. Moreover, this fleet is also increasingly visible throughout the North Atlantic region, achieving levels of activity – according to NATO's Maritime Command – not seen since shortly after the end of the Cold War. There is growing concern that, during a crisis, Russia would be able to constrain reinforcements transiting the Atlantic.

Clearly, the GN cannot respond to the full spectrum of threats and challenges in the Baltic and North Atlantic by itself. Instead, there is likely to be further focus on cooperation, both with regional navies in the Baltic and with NATO's major naval powers, including the United States, the United Kingdom and France.

CONCLUDING COMMENTS

Despite being relatively small compared with NATO's largest fleets, the GN is a sophisticated, network-centric navy that is able to deploy a wide range of effective warfighting capabilities. It is steadily expanding its capacity to execute war at sea in all three dimensions and – for the first time in 25 years – is targeted to grow in actual size. The process of renewal and investment – accompanied by a focus on career attractiveness – raises the prospect of a larger, properly manned and yet even more modern German Navy by 2030.[7]

International crisis management and conflict prevention have been cornerstones of GN strategy since the end of the Cold War and remain important. However, the changed security backdrop mean that national and collective defence – in other words combat – once again forms the key criterion governing both the GN's equipment procurement and training. However, no single nation can meet the maritime challenges of our time on its own. Accordingly, the German Navy will continue its traditional integration into a system of international alliances to achieve its mission.

Notes

1. The GN provides a substantial contribution to NATO´s four Standing Naval Forces (NATO Maritime Groups) on a regular basis and has done so for many years. Current major operations encompass NATO's Operation 'Active Endeavour' against international terrorism, the EU's Operation 'Atlanta' anti-piracy mission off East Africa and in the Indian Ocean, the refugee rescue and anti-people smuggling Operation 'Sophia' in the Mediterranean and participation in the United Nations Interim Force in Lebanon (UNIFIL).

2. The Baltic Commanders' Conference encompasses Denmark, Estonia, Finland, Latvia, Lithuania, Norway, Poland and Sweden as well as Germany.

3. *German Security Policy and the Future of the Bundeswehr* (Bonn: Federal Government of Germany, 2016). The core of security policy is based on a strategy based on mutual dependence with allies and partners, as reflected in the GN's own continued emphasis on multinational collaboration.

4. The development of the F125 design was described in detail in the editor's '*Baden-Württemberg* Class', *Seaforth World Naval Review 2018* (Barnsley: Seaforth Publishing, 2017), pp.116–31. *Baden-Württemberg* was formally commissioned on 17 June 2019.

5. See Guy Toremans, '*Braunschweig* Class Corvettes', *Seaforth World Naval Review 2013* (Barnsley: Seaforth Publishing, 2012), pp.129–46.

6. The Type 212 class is yet another German combatant previously described in World Naval Review. See the editor's 'Germany's Type 212A Submarines', *Seaforth World Naval Review 2014* (Barnsley: Seaforth Publishing, 2013), pp.136–52.

7. As for many fleets, recruiting and retaining sufficient personnel continues to be a significant issue. In partial mitigation of this problem, the GN is placing increasing reliance on automation and new technologies such as unmanned systems.

2.4C Fleet Review

Author:
Guy Toremans

THE FINNISH NAVY (SUOMEN MERIVOIMAT)

Becoming 'Leaner and Meaner'

The Finnish Navy's *Rauma* class fast attack craft *Porvoo* pictured at speed in June 2018. The Finish Navy's asymmetric approach to defence places considerable emphasis on fast, highly-mobile forces to conduct an effective defence of the country's coastline and maritime communications. *(Guy Toremans)*

As a neutral country Finland is under no illusions about the security challenges in the Baltic region. The deteriorating relations between the West and Moscow and the resurgence of the Russian Navy has placed northern European waters – and the Baltic Sea in particular – back on the front line.

More than most nations, Finland defines its maritime policy according to parameters dictated by its geography and climate. Located at the 'back' of the Baltic, the country is bordered by the sea on two sides – by the Gulf of Bothnia on its western side and the by the Gulf of Finland to the south-east. Additionally, the short distances between Finland and its neighbours make for strategic bottlenecks. The 675nm (1,250km) long coastline, broken-up by a complicated maze of over 81,000 islands, rocks and shoals, provides a robust physical deterrent to potential adversaries. However, significant proportions freeze up during the severe winter months, thus rendering the fleet practically inoperable. Consequently the Finnish Navy (*Suomen Merivoimat*) uses an asymmetric approach to defence, combining highly mobile forces with coastal defence and minelaying capabilities in order to inflict a high price on any invasion at the point of incursion.

The small but capable fleet maintains a high state of readiness, even in peacetime. When operating in

territorial waters, ships' commanding officers are provided with rules-of-engagement (ROE) options that give them the ability to progress through warning procedures to taking action to force a vessel to act as required without having to seek further authorisation from the Ministry of Defence.

HISTORICAL BACKGROUND

Finland declared its independence from Russia on 6 December 1917, with the Finnish Navy (FN) being formally established in the following July.[1] Its first ships were a mix of mostly obsolete vessels left behind in Finnish ports by the departing Russians, including a number of small torpedo boats and gunboats. However, in 1927 the Finnish parliament approved a major modernisation programme centred on the two innovative *Väinämöinen* class coastal defence battleships, supplemented by submarines and lighter craft. This fleet served Finland well during the so-called Winter War of 1939–40 and the following Continuation War of 1941–4 with the Soviet Union. The naval aspects of these conflicts were marked by extensive minelaying by both sides. *Väinämöinen*'s sister *Ilmarinen* was a major casualty when she sank on 13 September 1941.

After the end of the Second World War, the navy's size was dictated by the terms of the Paris Peace Treaty of 1947 with the victorious Allies. This stipulated that the maximum displacement of the fleet's ships should not exceed 10,000 tons and limited manpower to no more than 4,500. Submarines, torpedo craft and guided missiles were all prohibited. These restrictions were eased somewhat during the 1960s but were not fully removed until unilaterally revoked by Finland in the aftermath of German reunification in 1990.

Finland was a neutral country during the Cold War. This status was reflected in a policy that saw equipment acquisitions balanced between the Soviet Union and the West. There was also considerable emphasis on indigenous construction. A combination of treaty restrictions and financial constraints saw an emphasis on a strike force of light surface craft backed by significant mine warfare capabilities. Amongst the fleet's more notable designs were a series of progressively improved indigenous fast attack craft – the *Helsinki* class (commissioned 1981–6), the *Rauma* class (1990–2) and the *Hamina* class (1998–2006).

The immediate aftermath of the Cold War saw the FN focus on a 'Squadron 2000' concept that was to

Finland's geography and climate have a heavy impact on maritime strategy. For example, ice has a significant impact on winter operations in the harsh Baltic winter whilst shallow waters make minelaying particularly important. This picture shows the *Pansio* class minelayer *Porkkala* in winter ice. *(Finnish Navy)*

The Cold War Finnish Navy placed a significant emphasis on minelaying capabilities, represented here by this photograph of the now decommissioned minelayer *Pohjanmaa* visiting Portsmouth, UK in 2010. She was constructed at the then Wärtsilä Helsinki Shipyard in reflection of a shipbuilding policy that has placed significant emphasis on domestic naval construction. *(Conrad Waters)*

involve the acquisition of a mix of *Hamina* – then known as 'Rauma 2000' – class fast attack craft and light fast combat hovercraft type platforms known as T2000. However, the T2000 project was cancelled and it was decided to build additional 'Rauma 2000' platforms. The resulting four *Hamina* class vessels – along with the older *Rauma* class – continue to form the core of the FN's warfighting capabilities.

RESPONSIBILITIES AND MISSIONS

Finland's armed forces are focused on securing Finland's independence and territorial capability under a comprehensive security concept that places significant emphasis on collaboration with other national authorities. A system of universal male conscription provides a large military reserve that aids resilience in a large-scale or protracted conflict. Whilst Finland does not belong to any military alliance, it carries out practical cooperation with NATO and maintains the option of seeking NATO membership. Its status as an EU country is also significant.[2]

In line with this strategy, the FN's primary mission remains homeland defence. In practice this has three aspects, viz. (1) surveillance of the country's maritime borders and territorial waters; (2) repelling any potential violation of its territorial integrity; and (3) protecting its sea lines of communication and commercial shipping. With maritime challenges becoming more complex, diverse and unpredictable, missions to deal with asymmetric threats and crisis management have become an important part of this mix. As for the wider armed forces, dealing with these challenges is not a job for the navy alone: links with the Border and Coast Guards, the wider Ministry of the Interior, the Ministry of the Environment and other maritime bodies are essential. A good example of collaboration is provided by the MEVAT initiative; a chain of radars and electro-optical sensors strung along the coastline and controlled by stations in Upinniemi and Turku. MEVAT provides a maritime picture of the volume of traffic around the Gulf of Finland and the surveillance data thus gathered is shared amongst all partners.

ORGANISATIONAL STRUCTURE AND MANNING

The FN's current organisational structure is the result of a Defence Forces Reform announced early in 2012 and implemented by 2015. Conducted before the recent cooling in the West's relations with Russia, this saw a reduction in the defence forces' peacetime numbers from 15,000 to 12,000 and in mobilised strength from 350,000 to 230,000 to achieve a c. ten percent reduction in the defence budget. The resulting structure saw the FN focused on the Naval Command at Turku and four brigade-level units: the Coastal Fleet; the Coastal Brigade; the Nyland Brigade; and the Naval Academy. Logistics and administrative personnel were transferred to the new Armed Forces Defence Materiel Command and Defence Service Centre respectively. Although some of the cuts have subsequently been revisited – the wartime strength of the armed forces is now anticipated to reach 280,000 personnel – the FN's structure remains basically unchanged. Further details of the FN's constituent units are set out below:

A large proportion of the Finnish Navy's strength is allocated to land-based formations, principally the Coastal and Nyland Brigades. Assault landing craft such as the 'Jurmo' class *U-624* pictured here provide these forces with amphibious mobility. *(Guy Toremans)*

The Coastal Fleet: This comprises all combat vessels and auxiliaries. It is organised into the 4th Mine Countermeasures Squadron, the 6th Surface Warfare Squadron, the 7th Surface Warfare Squadron and the 8th Service Support Squadron, including the navy's transport units. The fleet's assets operate from two main naval bases – Pansio in the Archipelago Sea and Kirkkonummi in the Gulf of Finland.

The Coastal Brigade: The Brigade is headquartered at the Upinniemi base at Kirkkonummi and comprises:

- **The Suomenlinna Coastal Regiment** made up of an anti-ship missile battery, a communications company, a coastal company, a coastal artillery battery and the Section Leader School.[3]
- **The Naval Reconnaissance Battalion,** encompassing the Combat Diver School, the Special Operations Detachment and the Naval Reconnaissance Company.
- **The Porkkala Coastal Battalion** that manages the brigade's support and maintenance activities.

The Nyland Brigade: Also referred to as the Uusimaa Brigade, this provides the FN's naval infantry and is headquartered in Raasepori.[4] It encompasses:

- **The Vasa Coastal Jaeger Battalion,** made up of the 1st Coastal Jaeger Company, the 2nd Coastal Jaeger Company and the NCO School.
- **The Ekenäs Coastal Battalion**, comprising a mortar company, a headquarters and signals company and a combat engineer company.
- **A Logistics Centre.**

The brigade, consisting of about 200 regular personnel, trains the coastal jaegers and is the only one in Finland offering training in Swedish. On an annual basis, the Nyland Brigade trains approximately 1,500 conscripts, around one percent of whom are women. The brigade utilises XA-185 Pasi APCs and trucks for land transport, as well as *Jehu*, *Jurmo*, *Meriuisko* and 'G' class landing craft for amphibious transport.

The Naval Academy: This also houses the Naval Research Centre and the Navy Combat Centre. It is located in the Suomenlinna Sea Fortress, a tiny island and UNESCO World Heritage Site lying a 15-minute ferry ride from Helsinki city centre. Every year some 350 naval cadets, enlisted personnel seeking to become petty officers and conscripts seeking to become reserve officers enter the academy.

As of mid-2019, the FN employed 1,212 uniformed personnel, comprising 471 officers, 218 warrant officers and 523 NCOs. There were also an additional 203 civilians, whilst a total of around 3,200 conscripts are trained each year. The latter serve for either 165, 255 or 347 days, depending on the training they require. Conscripts trained for normal duties will serve for 165 days, those requiring a special competence for 255 days and those being trained as reserve officers or non-commissioned officers for 347 days. Most are destined for the coastal defence brigades and only some twenty percent serve onboard ships. In wartime, the availability of trained conscripts could allow the number of naval personnel to grow to up to c. 30,000.

FLEET COMPOSITION

The *Suomen Merivoimat* is a very effective naval force that operates a relative modern fleet focused on fast missile attack craft, minehunting and minelaying vessels, supported by numerous auxiliaries and smaller craft. In wartime the FN can also

Although Finland has largely abandoned its fixed artillery positions such as the preserved 12in battery on Kuivasaari Island – seen here firing a 'water shot' – the Coastal Brigade's Suomenlinna Regiment now deploys mobile surface-to-surface missiles, primarily the truck-mounted Saab RBS15-SF. *(Guy Toremans)*

Table 2.4C.1: FINNISH NAVY – PRINCIPAL UNITS AS AT MID-2019

TYPE	CLASS	NO.	YEAR[1]	TONNAGE	DIMENSIONS	SPEED	PRINCIPAL ARMAMENT
Surface Combatants (8)							
Attack Craft (FAC)	**RAUMA**	4	1990	240 tons	48m x 8m x 2m	30 knots+	1 x 40mm, 6 x SSM, 2 x ASW mortars, mines & depth charges, light weapons
Attack Craft (FAC)	**HAMINA**	4	1998	275 tons	51m x 8m x 2m	30 knots+	1 x 57mm, 6 x SSM, 8 x VLS SAM, mines & depth charges, light weapons[2]
Minelayers (5)							
Minelayer (ML)	**PANSIO**	3	1991	610 tons	43m x 10m x 2m	11 knots	Mines, light weapons
Minelayer (ML)	**HÄMEENMAA**	2	1992	1,500 tons	78m x 12m x 3m	20 knots	1 x 57mm, 8 x VLS SAM, 2 x ASW mortars, mines & depth charges, light weapons
Mine Countermeasures Vessels (9)							
MCMV	**KUHA**	3[3]	1974	150 tons	32m x 7m x 2m	11 knots	Light weapons
MCMV	**KIISKI**	4[3]	1982	20 tons	16m x 4m x 1m	11 knots	Light weapons
MCMV	**KATANPÄÄ**	3	2012	680 tons	53m x 10m x 3m	13 knots	1 x 40mm, mines & depth charges, light weapons
Amphibious Assault Craft (c.115)							
LCP	**MERIUISKO** (U-200/300/400)	c.30[4]	1983	8 tons	11m x 4m x 1m	30 knots+	Light weapons, 2.5 ton or c.25 troop capacity
LCP	**JURMO** (U-600)	38	1999	14 tons	14m x 4m x 1m	30 knots+	Light weapons, 3 ton or c.20 troop capacity
LCP	**JEHU** (U-700)	12	2014	32 tons	20m x 4m x 1m	35 knots+	Light weapons, 6 ton or c.25 troop capacity
LCP	**'G'**	35	2001	2 tons	8m x 2m x 1m	30 knots+	Light weapons, 1 ton or c.10 troop capacity

Auxiliary and Non-combatant vessels include 3 pollution control ships, 4 training vessels and c.10 transport and command craft.

Notes:
1. Date relates to the date the first ship of the class entered service with the Finnish Navy. In some cases, these ships are now retired.
2. Armament in the course of being modernised, see text for details.
3. In course of being decommissioned.
4. Some are being withdrawn.

Naantali is the final unit of the four *Rauma* class fast attack craft. All four *Rauma*s were modernised in the first half of the current decade and have a particular emphasis on anti-submarine warfare. Along with the two *Hämeenmaa* class minelayers, they will be replaced by the new Squadron 2020 corvettes. *(Guy Toremans)*

rely on privately-owned boats earmarked for auxiliary tasks. Principal units are listed in Table 2.4C.1 and are detailed further below.

MISSILE-ARMED FAST ATTACK CRAFT

The heart of the sea service's strike capabilities are the four *Rauma* class and the four *Hamina* class fast missile attack craft.

***Rauma* class:** The four 240-ton *Rauma* class units, developed from the previous and now retired *Helsinki* class fast attack craft, entered service between October 1990 and June 1992. From 2010 onwards the ships received a €70m upgrade that included the installation of Saab's 9LV Mk 4 combat management system; a Sea Giraffe radar; a Simrad ST2400 variable-depth sonar; and two Rheinmetall MASS decoy systems. The interiors of the 48m long vessels were also renovated while the MBDA Mistral short-range surface-to-air missile systems were removed. This retrofit was intended to allow the vessels to remain in service into the 2020s but fatigue fractures in their aluminium structures that emerged after the work was completed led to temporary lay-up and have impacted overall lifespan.

Tornio is one of the Finnish Navy's four *Hamina* class fast attack craft. They are a development of the previous *Rauma* class, incorporating a composite superstructure and placing a particular emphasis on stealth characteristics. *(Guy Toremans)*

***Hamina* class:** The four *Hamina* class fast missile attack craft were procured under the 'Squadron 2000' project. Commissioned between August 1998 and June 2006, the 275-ton, 51m-long units are, in turn, an evolution of the *Rauma* design. They have an aluminium hull and fibre-reinforced plastic composite superstructure, with shaped surfaces and radar-absorbent coatings to reduce their radar cross section. Submerged engine exhausts bleed exhaust gases into the seawater to limit the vessels' infra-red signatures whilst all machinery acting as a significant noise source is installed on resilient mountings to minimise acoustic emissions. Extremely potent vessels for their size, the craft are also highly manoeuvrable. They can perform a 360-degree turn within a diameter of little more than 50m whilst reverse thrust can bring the vessels to a standstill from their maximum speed of 30 knots within 200m. The downside is that the units are not that comfortable in bad weather and have only limited space for fuel and provisions.

Between 2019 and 2023 the *Hamina* class will undergo a mid-life upgrade (MLU) programme – known as the 'Squadron 2020 MLU' – to keep them in operation well into the 2030s. Reported to cost around €225m, work includes installation of new Saab 9LV combat management and TactiCall communications systems. Their existing surface-to-surface missiles will be replaced by the latest variant of IAI's Gabriel and Trackfire remote weapon stations will be installed. In addition, the existing TRS-3D radar and the CERO fire-control systems will be upgraded, the Bofors 57mm Mk3 guns replaced with lighter Bofors 40mm Mk4 guns and their 'at-sea' endurance extended by installing larger fuel tanks. It is also intended to provide the class with an anti-submarine warfare capability by transfer of the STS2400 variable-depth sonar systems from the *Rauma* class as they retire and the acquisition of Saab's new lightweight Torped 47.

MINE WARFARE ASSETS

Mine warfare operations remain a central element of the Finnish Navy's operating concept given that the local geography's narrow, shallow straits and

Built by Intermarine in Italy, the three *Katanpää* mine-countermeasures vessels acquired under the MCMV 2010 programme were transported to Finland by heavy lift ship after completion. This photograph shows the lead ship arriving in Finland in June 2012. *(Finnish Navy)*

myriad islets make it highly suitable for minelaying. As a result, the FN has an extensive and modern suite of both mine countermeasures and minelaying equipment.

***Katanpää* class:** Originating from plans made in the early years of the new Millennium, the three *Katanpää* class vessels were ordered from at Intermarine's Sarzana Shipyard near La Spezia in 2006 under the 'MCMV 2010' programme. The design is derived from the *Gaeta* class minehunters in service with the Australian, Italian and Thai fleets.[5] The *Katanpää* design is essentially an evolution of the two *Lat Ya* class vessels delivered to the Royal Thai Navy in 1999.

Construction of the lead ship began in July 2007. She was scheduled to enter service in 2010 but heavy flood damage to the Intermarine Shipyard in 2009 delayed her commissioning. Sea trials finally commenced in 2011 and – upon completion of her acceptance trials in the Mediterranean – the minehunter was formally delivered to the FN on 4 May 2012. Loaded onboard the Dutch BigLift Shipping vessel M/V *Happy Dover*, the 52.5m-long minehunter left La Spezia on 21 May and was off-loaded at Pansio Naval Base in early June 2012. Work on the second vessel – *Purunpää* – commenced in March 2008, and the keel of the third and final minehunter *Vahterpää* was laid down in February 2009. Both minehunters were also piggy-shipped to their homeport of Pansio after delivery on 20 August 2013 and 2 November 2016 respectively.

A major innovation in the class is use of a new type of glass fibre-reinforced plastic hull conceived specifically for the FN. Use of a proprietary construction technique – known as an Unstiffened Monocoque Single Skin – means that the hull is much thicker (up to 150mm at the hull bottom) than in traditional fibre-reinforced plastic vessels. As a result, the ships are the strongest and only ice-going minehunters in the world. A comprehensive mine-countermeasures package includes hull-mounted echo sounders and towed side-scanning sonar, supplemented by additional systems mounted on Kongsberg HUGIN and REMUS autonomous underwater vehicles. There are also two types of remotely-operated vehicles (ROVs) in the inventory: Saab's reusable, multi-functional Double Eagle Mk III and Atlas Elektronik's SeaFox, the latter in both disposal (SeaFox C) and reusable identification (SeaFox I) versions. These systems have a high degree of commonality with those found on Swedish and many NATO minehunters, providing excellent opportunities for interoperability. For example, *Vahterpää* conducted NATO Evaluation Level 2 in the course of the Northern Coasts 2018 exercise.

The class is also equipped with a 40mm Bofors gun and some reports state depth charges and/or mines can also be embarked. This allows performance of surveillance, sea lane protection and harbour defence duties in addition to the core MCM role. Endurance is 1,500 nautical miles, making the class suitable for out-of-area deployment.

***Kuha* and *Kiiski* classes:** The FN also operates a small number of 'legacy' inshore minesweepers of the 1970s vintage *Kuha* and 1980s era *Kiiski* classes, the former having been modernised around the turn of the Millennium. Both classes can undertake acoustic and magnetic mine clearance operations. The ships are being withdrawn as the *Katanpää* class reach full operational capability. It is intended to replace their sweeping capabilities with a remotely controlled minesweeping system.

***Hämeenmaa* class:** The minelayers *Hämeenmaa* and *Uusimaa*, both commissioned into the fleet in 1992, are currently the FN's largest combatants. They underwent a major upgrade between 2006 and 2008 to replace obsolescent equipment and make them better suited for international missions beyond the Baltic. In 2008, *Uusimaa* deployed to the Mediterranean to test the newly-fitted equipment, the upgraded ships subsequently being NATO certified.

The mid-life modernisation included substantial physical changes. The original bow door was replaced with a fixed structure, two new masts were fitted to the superstructure to accommodate an expanded sensor and communications fit, the fuel and water tanks enlarged and stabilisers fitted. A flight deck was installed aft to support light helicopter operations. Internal revisions provided a surgical facility, officer accommodation and a new galley and dining area, whilst a new combat information centre was equipped with the EADS ANCS 2000 combat management system. New sensors

Uusimaa, one of two *Hämeenmaa* class minelayers, joined the fleet on 2 December 1992. The minelayers received a major upgrade between 2006 and 2008 to facilitate their ability to undertake 'out of area' deployments. *(Guy Toremans)*

With a length of 43m and displacement of c. 610 tons, the three landing craft utility-type *Pansio* class minelayers – the lead ship is pictured here – have a draught of just 2m that enables them to operate in very shallow waters. They have recently completed an extensive overhaul aimed at keeping them in service throughout the next decade. The ships can also double-up as support ships for the provision of fuel, water and ammunition for smaller vessels and embark ten TUE containers. *(Guy Toremans)*

included the EADS TRS 3-D radar whilst armament upgrades included a new Bofors 57mm/70 Mk1 gun and Denel Umkhonto VL missile system.

***Pansio* class:** The three ice-strengthened *Pansio* class landing craft utility (LCU)-type minelayers – *Pansio*, *Porkkala* and *Pyhäranta* – joined the fleet in the early 1990s. As well as their primary minelaying task, they also have a military lift capacity of 200 troops or 100 tons of equipment. Like many other FN vessels, they have completed an extensive midlife overhaul and should remain in service for at least another decade. In addition to new machinery and weapons systems, the upgrades included a complete overhaul of the interior and enhancements to the fuel system and equipment to facilitate the transfer of fuel and water to smaller vessels.

The FN stocks a variety of sea mines for minelaying operations. These include S/43 and S/58 anchored electromagnetic mines for anti-surface warfare, PM/83 and PM/83-2 (Russian MDM-2 and MDM-1) acoustically influenced/magnetic ground mines for anti-surface and anti-submarine warfare and PM/85 (British Stonefish) acoustic/magnetic mines with pressure-influence settings.[6]

AUXILIARIES AND SERVICE CRAFT

Aside from the missile attack craft and mine warfare units, the FN numbers various auxiliaries, small landing craft and service launches.

The FN's landing craft form an important part of the fleet. They frequently operate in conjunction with its land-based formations, notably the Nyland Brigade. There are numerous craft in different configurations. The most recent addition is an initial batch of twelve 20m 'Jehu' class (U-700) high speed assault craft that entered service from 2014. Displacing 32 tons, they have an aluminium hull and composite superstructure. They can transport around twenty-five fully-equipped troops in a ballistically and NBC protected cabin at sustained speeds

The Finnish Navy operates large numbers of assault landing craft, primarily in support of its land-based formations. The most modern are the twelve strong 'Jehu' or U-700 class, which were ordered from the Finnish shipbuilder Marine Alutech in October 2012. This photograph shows the lead vessel of the class, *U-701*. *(Guy Toremans)*

Large numbers of 'Meriuisko' class landing craft of different variants remain in Finnish Navy service. *U-313* is one of the U-300 series, which were delivered by Marine Alutech during the 1980s. *(Guy Toremans)*

of 35 knots. A flexible weapons outfit includes a Saab Trackfire remote weapons station equipped either with a 12.7mm heavy machine gun or a 40mm automatic grenade launcher and other heavy machine gun positions.

The core of troop transportation capabilities is provided by the thirty-eight 'Jurmo' class (U-600) landing craft personnel, which were delivered from the late 1990s onwards. They are capable of carrying twenty-two troops or three tons of cargo. Around thirty older 'Meriuisko' class LCPs of the U-200, U-300 and U-400 series also remain in service, although it seems some have been earmarked for disposal. The larger landing craft are supplemented by thirty-five 8m-long 'G-class' raiding craft, which entered service between 2001 and 2006 and are able to carry nine fully-equipped troops.[7]

These front-line vessels are also supplemented by a number of transport and command launches, training and support vessels and yard craft. Given that the FN's tasks include the control of marine pollution, its inventory also includes three pollution control vessels – the 3,500-ton *Louhi* commissioned in April 2011 (the largest spill-recovery ship in the Baltic region) – and the smaller and older *Halli* and *Hylje.* Although ultimately owned by the Ministry of the Environment, the ships are under naval control and have a secondary logistical support function.

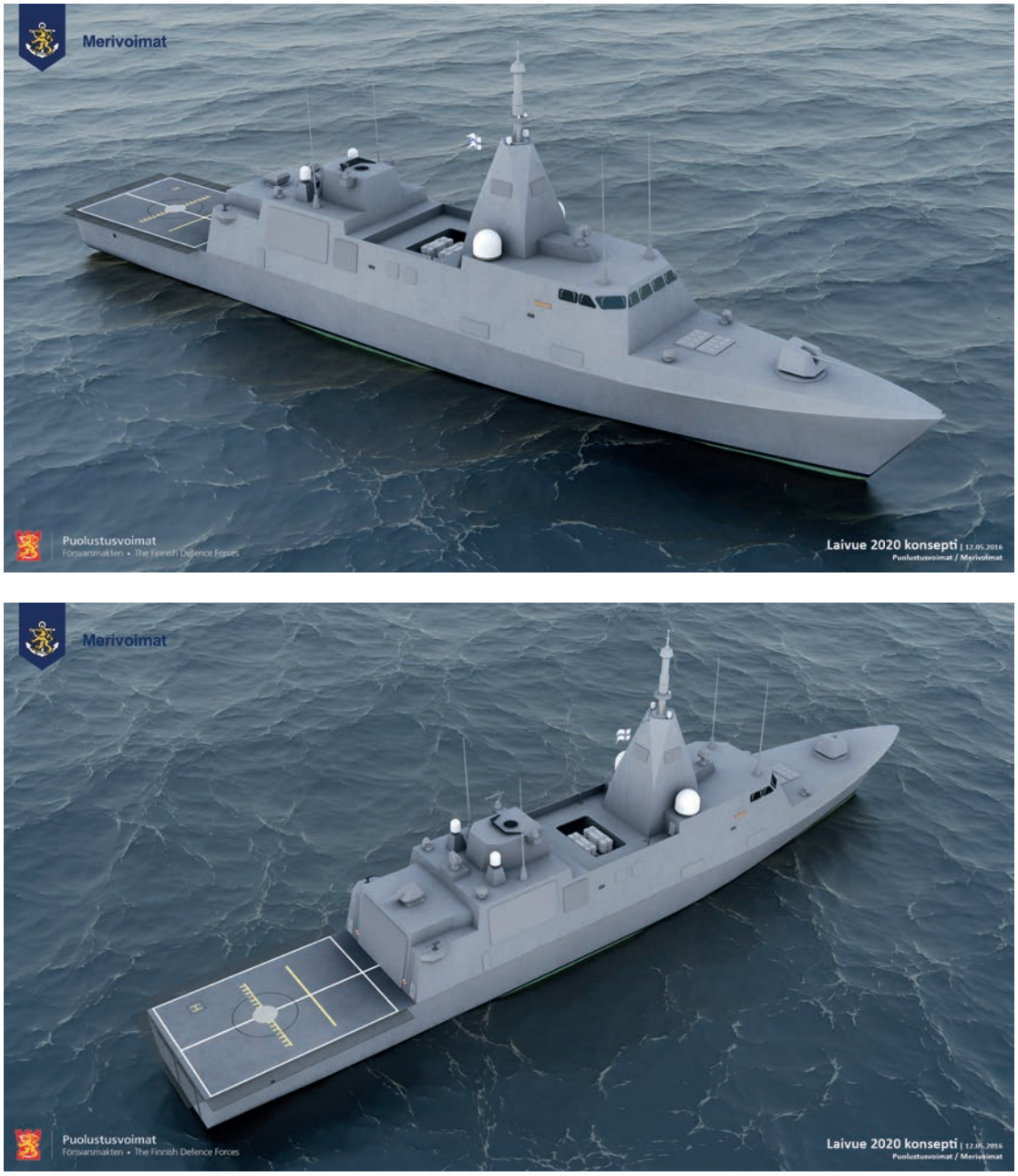
PROCUREMENT POLICY AND REPLACEMENT PROGRAMMES

The navy's procurement programmes are run by the MoD's Materiel Unit (MU). The MU prepares material policy and directs projects for defence as well as international cooperation and supports local defence companies' participation in defence procurements, as well as their involvement in the international defence market to promote exports. The MU also handles the procurement activities

The Finnish Navy maintains a significant force of auxiliaries in addition to its front-line warships. The largest are three pollution control ships, which are owned by the Ministry of the Environment but operated under naval control. *Louhi*, seen here in 2012, has 1A Super ice operations classification, allowing the ship to operate in thick winter ice. She is designed to recover spilled oil and chemicals in both open water and ice conditions, to extinguish shipboard fires and for the emergency towing of ships. She also has a secondary logistical support role. *(Guy Toremans)*

through the Nordic Defence Cooperation (NORDEFCO) and NATO Partnership for Peace (PfP).

By far the most important current naval procurement programme is the Squadron 2020 ('*Laivue* 2020') project. Estimated to cost €1.2bn (US$1.35bn), this involves the replacement of seven ships – the decommissioned minelayer *Pohjanmaa* and the existing *Rauma* and *Hämeenmaa* classes – with four new multipurpose corvettes. The new ships have been designed to provide a year-round, high-endurance presence in all Baltic weather conditions and will enhance the FN's ability to conduct warfare on the open seas. The programme was formally launched in September 2015 after several years of development and a design contract was signed with the proposed builder, Rauma Marine Constructions, in April 2017. This was followed by a letter of intent relating to the construction phase in October 2018. It seems that the original intention was to conclude a formal construction contract in the first half of 2019 but as of June 2019 negotiations were still ongoing. Towards the end of the month the Ministry of Defence confirmed that there were still 'open issues' that required resolution with Rauma Marine Constructions before a final contract could be agreed. This delay looks set to push back the start of the construction phase to 2020. The first corvette was initially set to start sea trials in the course of 2024 and this inevitably now looks open to some doubt in consequence. However, it seems that the original aim of bringing all four Squadron 2020 ships into operational service by 2028 remains the current intention. The new ships – also to be known as the *Pohjanmaa* class – are expected to displace around 3,200 tons and be a little over 100m in length, therefore rivalling the old coastal defence battleships in size. Concept images show what looks like a scaled-up version of the *Hamina* class. The vessels will be capable of anti-surface, anti-submarine and anti-air operations, be equipped with the usual minelaying capability and also have the ability to embark a small staff for command purposes. Much of the class's equipment has already been selected – it includes a BAE Systems' Bofors 57mm gun, Raytheon's RIM-162 Evolved Sea Sparrow Missiles (ESSM), IAI's Gabriel surface-to-surface missiles as well as a Saab combat management system and Torped 47 lightweight torpedoes. There will be both a helicopter deck and hangar. Diesel propulsion will balance speed and endurance so as to allow the possibility of out-of-area deployment.[8]



The Squadron 2020 ('*Laivue* 2020') Offshore programme involves the construction of four multi-purpose corvettes known as the *Pohjanmaa* class. Concept images dating from mid-2016 suggest the likely design will be akin to a scaled-up version of the *Hamina* class fast attack craft. *(Finnish Navy)*

Although the Squadron 2020 vessels are intended to form the backbone of the navy's capabilities from the late 2020s onwards, the FN is keen to place the programme in the context of other modernisation projects, including modernisation of the *Hamina* and *Pansio* classes and the recently completed MCMV 2010 programme. Continued investment in the land-based surface-to-surface missile batteries and coastal units is also regarded as being important.

A Finnish Navy *Rauma* class fast attack craft seen operating with the US cruiser *Vella Gulf* (CG-72) during the 'Baltops 2003' exercises. Finland is a member of NATO's Partnership for Peace Programme and has been a regular participant in NATO exercises since the mid-1990s. However, there is little popular support for Finnish membership of the Alliance. *(US Navy)*

The now-decommissioned Finnish minelayer *Pohjanmaa* operating with the Royal Danish Navy's support ship *Absalon* during the 'Baltops 2013' exercises. In addition to its links with NATO, the Finish Navy retains significant bilateral and multilateral ties to the Nordic fleets. *(US Navy)*

COOPERATION AND PARTNERSHIPS

The dense seaborne traffic in the Gulf of Finland and wider Baltic, the rise in asymmetric dangers in the post-Cold War period and the recent re-emergence of a traditional military threat all mandate a focus on maritime situational awareness and security. The FN appreciates that international cooperation has to be integral to the navy's way of operating if it is to meet these challenges successfully in spite of its formal military non-alignment.

Finland became part of NATO's Partnership for Peace (PfP) programme in 1994 and joined the European Union (EU) – and hence became subject to its Common Security and Defence Policy (CSDP) the following year. Finland's commitment to its EU responsibilities is very strong and it regularly assigns assets to EU security operations. The FN has also become increasingly engaged in multinational exercises organised in the region, participating in NATO's 'Baltops' exercises since the mid-1990s and the 'Northern Coasts' series from 2007 onwards. Participation in these manoeuvres allows the navy to benchmark it against NATO and other European navies, as well as to operate more smoothly with multinational task groups.

The FN has particularly strong links with its Swedish counterpart, as evidenced by the sharing of sea surveillance and situational awareness under the Surveillance Co-operation Finland-Sweden (SUCFIS) system since 2006. This led to the expanded Sea Surveillance Cooperation Baltic Sea (SUCBAS) arrangements encompassing many of the Baltic countries, as well as the United Kingdom. Naval cooperation between Finland and Sweden also extends to the development of a joint Swedish-Finnish Naval Task Group (SFNTG), which achieved initial operating capability in 2017 and is intended to reach full operational capacity by 2023.[9] An example of broader regional collaboration is the Nordic Defense Cooperation (NORDEFCO). This is intended to help the participant states – Denmark, Finland, Iceland, Norway and Sweden – coordinate defence projects in areas such as procurement, logistics and training.

Although the development of crisis-management capabilities and contributions to both the EU and NATO operations are ongoing, the option of NATO membership remains controversial and is considered unlikely. Recent surveys show that only around twenty percent of the population want to join the Alliance.

CONCLUSIONS

At a time when Finland faces a strategic challenge of maintaining stable relations with Russia to the east while also working with its European Union and other 'Western' partners, the Finnish Navy continues to remain a key instrument of the country's comprehensive defence policy. The sea service's aim is to deliver the optimum structure, force levels and operational outputs within a tight budgetary framework. The innovative Squadron 2020 programme is currently key to the achievement of this ambition, leading the way in terms of the fleet's modernisation.

The progress towards delivering Squadron 2020 has been assisted by a more positive budgetary position following the reductions in the middle of the decade. Defence spending in 2019 amounted to €3.138bn, the near ten percent increase on the previous year being heavily influenced by Squadron 2020 allocations. However, Finland's recent elections have seen a shift in the country's political balance and the future budgetary environment may not be so stable. Whilst Squadron 2020 is probably too advanced to be at risk in spite of the recently announced delay to the construction contract, the challenge of funding future modernisation in the face of developing operational requirements may be more significant. The navy will need to continue to innovate and use new technologies to maintain progress.

The *Hamina* class – *Hanko* is pictured here – are being modernised to complement the new Squadron 2020 corvettes. Although good progress has been made in upgrading the Finnish Navy in recent years, funding the continued modernisation required by developing technological and operational changes will be a challenge. *(Guy Toremans)*

Notes

1. Finland came under Swedish rule in the thirteenth century. Swedish rule ended with the Treaty of Hamina signed on 17 September 1809, which concluded the Finnish War fought between Sweden and Russia. This saw the eastern third of Sweden becoming the autonomous Grand Duchy of Finland, within the Russian Empire, a status which persisted until the Russian Revolution. During the period of Russian rule, Finnish ships operated alongside the Baltic fleet of the Russian Imperial Navy.

2. Finland's current defence strategy and priorities are set out in the *Government's Defence Report* (Helsinki: Prime Minister's Office Publications, 2017). An English language version is currently available at: https://www.defmin.fi/files/3688/J07_2017_Governments_Defence_Report_Eng_PLM_160217.pdf

3. The coastal artillery units have largely moved away from fixed and towed guns to truck-mounted and infantry-carried anti-ship missiles; respectively the Saab RBS-15SF and Spike-ER systems. However, a number of fixed 130mm 53 TK coastal batteries installed between 1984 and 1990 are believed to remain operational.

4. The Finnish region of Uusimaa is bi-lingual; Uusimaa translates to Nyland in Swedish.

5. *Gaeta* class derivatives have also subsequently been ordered by Algeria and Taiwan.

6. See Norman Friedman, *The Naval Institute Guide to World Naval Weapon Systems: Fifth Edition* (Annapolis: Naval Institute Press, 2006), p.778.

7. The 'Jehu', 'Jurmo', 'Meriuisko' and 'G' class vessels currently in service have all been manufactured by Finland's Marine Alutech OY AB, being respectively designated by the company as their Watercat M18 AMC, Watercat M12, Watercat M11 and Watercat M8 designs. Interestingly, the company's list of deliveries at: http://www.marinealutech.com/references suggests only twenty-four U200, U300 and U400 series *Meriuisko* class vessels were delivered to the FN.

8. The Finnish Ministry of Defence currently maintains a website on the Squadron 2020 programme at: https://www.defmin.fi/en/administrative_branch/strategic_capability_projects/squadron_2020/squadron_2020

9. A good, if slightly dated, overview of the history of defence co-operation between Finland and Sweden is provided by Charly Salonius-Pasternak's *FINA Briefing Paper 163 – Deeper Defence Cooperation: Finland and Sweden together again?* (Helsinki: The Finnish Institute of International Affairs, 2014) and currently available at: https://www.files.ethz.ch/isn/186091/bp163.pdf. More recent analysis by Mr Salonius-Pasternak of the consequences of this collaboration can be found by searching the FINA website.

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3.1 SIGNIFICANT SHIPS

PROJECT 28 KAMORTA CLASS

The Indian Navy's Indigenous Corvette Design

Author:
Mrityunjoy Mazumdar

In the early 1990s, the Indian Navy's surface ship design group (SSG) at the Directorate of Naval Design (DND) came up with the idea of a simple, completely indigenous, anti-submarine warfare platform. Displacing around 2,500 tons, the new ships would be the workhorses of the navy, replacing the relatively numerous 'Petya' and *Nilgiri* (*Leander*) class vessels that were entering their decommissioning cycle.

The project was initiated by the then Director General of Naval Design in around 1995. The initial feasibility report was rejected by the financial authorities. However, by late 1998 financial approval to start preliminary design work was finally obtained. By the start of the new millennium, the project had commenced in earnest.

Key roles envisaged for the new ships included:

- Provision of anti-submarine warfare (ASW) capability to a carrier battle group.
- The operation and control of embarked anti-submarine helicopters.
- Acting as anti-submarine warfare surveillance and control platforms.
- Providing anti-submarine protection to merchant vessels on major trade routes close to home ports.
- Searching for, locating and destroying submarines in designated areas.

The new ships could also be tasked with providing support for amphibious operations and undertaking low intensity maritime operations.

Left: The lead Project 28 *Kamorta* class corvette pictured arriving in Singapore's waters at the time of the city-state's 50th anniversary international fleet review in May 2017. The Project 28 design originates from design studies initiated in the 1990s to replace aging anti-submarine warfare vessels. *(Singapore Ministry of Defence)*

DESIGN DEVELOPMENT

The new project followed closely on the heels of that for the Project 17 *Shivalik* class stealth frigates.[1] Accordingly, the new design drew heavily on lessons learned from the preceding programme. Key design drivers were low radiated noise, a low radar cross section and a minimal infrared signature. Crucially, a requirement to reduce radiated underwater noise below that specified for the Project 17 design meant the specification of a raft-mounted propulsion system, a first for an Indian Navy warship. Another key stealth feature was the adoption of an 'X'-form cross section, another first for the DND. In line with other contemporary warship designs, the use of exposed fittings was to be kept to a minimum.

Internally there were 'spirited' discussions over the choice of power plant. According to a former Head of DND, Rear Admiral N P Gupta, IN (rtd), who was involved in this project, one camp advocated the use of gas turbines; another diesels. Eventually the diesel option favoured by then Commodore Gupta won. Whilst lighter MTU diesels were considered, a desire to maximise indigenous content saw locally-assembled Pielstick diesels being preferred.

Hull model testing was undertaken in a high-speed towing tank at the Visakhapatnam-based Naval Science & Technological Laboratory (NSTL) between 2003 and 2004. In addition to a range of standard tests, evaluation was performed on two types of bow-mounted sonar domes. These included computational fluid dynamics analysis of flow around the domes and cavitation inception tests

As the design that was designated the Project 28 corvette evolved, the ship grew larger as additional weapons and sensors were added. This resulted in some fairly major changes, including to the hull structure. Eventually a c. 2,500-ton concept was to grow to a displacement of well over 3,000 tons.

PROGRAMME APPROVAL

By 2003, the Indian Navy was ready to proceed. In March 2003, it submitted a proposal through the Ministry of Defence to India's Cabinet Committee on Security (CCS) seeking approval for the construction of four anti-submarine warfare corvettes. Garden Reach Shipbuilders & Engineers (GRSE) in Kolkata was nominated to perform the work which was estimated to cost INR2,871.27 crore (INR28.7bn) – c. US$620m – inclusive of excise duty and a foreign exchange content of INR564.52 crore (INR5.6bn).[2] The corvettes were planned for induction between 2008 and 2012 with

Steel hull block sections for the third Project 28 frigate, Yard No 3019 *Kiltan*, pictured at builders GRSE before the start of ship assembly in 2010. Formal approval for the Project 28 programme was obtained in March 2003 before the design had fully evolved. This premature approval was to have a significant impact on the overall programme; *Kiltan*'s keel was not laid until August 2010 and delivery occurred in October 2017. *(Mrityunjoy Mazumdar)*

A photograph of the formal keel-laying ceremony for *Kamorta,* Yard No. 3017, on 20 November 2006. Like the third member of the class*, Kiltan*, she was assembled on a conventional inclined slipway and launched into the adjacent Hooghly River. *(GRSE)*

the aim of partially arresting the decline in the Indian Navy's ASW assets.

The proposal submitted to the CCS called for a largely indigenous weapons and sensor fit. It was to include a hull-mounted sonar, an active towed array, an advanced torpedo defence system, an underwater telephone, expendable bathythermographs and an ASW fire-control system. The ship would carry torpedoes, two ASW rocket launchers and depth charge launchers. They would be able to house an advanced light helicopter and also incorporate a telescopic hangar for a Sea King-sized helicopter as an alternative.

Table 3.1.1: *KAMORTA* CLASS LIST AND CONSTRUCTION SCHEDULE

NAME	YARD NO	PRODUCTION PLAN			KEEL LAID	LAUNCHED	DELIVERED	CONSTRUCTION
		Start[1]	Delivery[1]	Timescale	Actual Date	Actual Date	Actual Date	Actual Timescale[2]
Kamorta (P28)	3017	2004	2008	c. 48 months	20 November 2006	19 April 2010	12 July 2014	92 months
Kadmatt (P29)	3018	2005	2009	c. 48 months	27 September 2007	25 October 2011	26 November 2015	98 months
Kiltan (P30)	3019	2007	2011	c. 48 months	10 August 2010[3]	26 March 2013	14 October 2017	86 months
Kavaratti (P31)	3020	2008	2012	c. 48 months	20 January 2012[3]	19 May 2015	[late 2019]	[>90 months]

Notes:

1. Information provided in *Report No.19 of 2017 of the Comptroller and Auditor General of India.* The planned 'drum beat' between each ship was 18 months.

2. Date from keel laying to delivery. Steel cutting would have commenced significantly earlier; reportedly on 6 Aug 2005 for *Kamorta.* However, there are significant differences in information on start dates, even from official sources.

3. The delay in keel laying for *Kiltan* and *Kavaratti* may partly reflect late procurement of their composite superstructures. Waiting for previous ships to clear building berths may have been an additional factor.

The proposal was duly approved by the CCS on 29 March 2003. Around this time, the Ministry of Defence issued a letter of intent to GRSE to kick off the project. GRSE's in-house design team – the Central Design Office – was roped in by the DND to perform hull testing as well as to undertake the detailed design of the ships. This was yet another first for warship design in India. For various reasons, a formal contract would not be signed with GRSE until 2012, by which time construction was well underway.[3]

CONSTRUCTION AND DELIVERY

The issue of the Ministry of Defence's letter of intent effectively started the detailed design and construction process at GRSE in spite of the continued evolution of the design and a lack of a formal contract. Table 3.1.1 summarises key production milestones for the project.

GRSE built the first and third Project 28 hulls on an inclined building berth and the second and fourth in a dry dock. The shipyard's hull shop was upgraded to allow construction of 65-ton hull blocks. The complex of building berths along the Hooghly River was also enhanced to facilitate the building process.

Both the fabrication and outfitting of many hull blocks was sub-contracted to smaller shipyards and engineering firms. Many other aspects of the building process including cable-laying, piping, electrical work were also outsourced. This process of outsourcing was extended to important elements of the detailed design under the overall control of GRSE's Central Design Office. For example, India's Axsys Technologies undertook 3D modelling using Tribon software and provided detailed production designs encompassing much of the piping and electrical outfit.

The first hull – Yard No 3017 – was named *Kamorta* and launched on 19 April 2010 when about forty percent complete.[4] Her maiden sea trials commenced in June 2013. During a later set of trials in late October 2013, she ran aground on the banks of the Hooghly River near Geonkhali.[5] Delivered in July 2014, she was commissioned the following month at her home port of Visakhapatnam, headquarters of the Indian Navy's Eastern Naval Command and Fleet.

The next in class, *Kadmatt*, was launched on 25 October 2011 when approximately fifty percent of the total work had been completed, representing a significant improvement over that achieved with the first of class. Delivery took place in late November 2015 and was followed by commissioning at Visakhapatnam in January 2016.

The third in class, *Kiltan*, was launched on 26 March 2013. In contrast to the two earlier ships she was fitted with a composite superstructure to help reduce her top weight. Her sea trials commenced on 6 May 2017. GRSE set a new record for itself by completing contractor's sea trials during the first trial sortie. According to a contemporary Indian Navy press release, the trials also departed from previous practice in that they acted as a pilot for the testing of all major weapons and sensors as an integral part of the trials programme. *Kiltan* was handed over to the navy on 14 October 2017 and commissioned just two days later, again at Visakhapatnam.

The last member of the class, *Kavaratti*, was launched on 19 May 2015. Sea trials were expected to have commenced in March 2019 and be followed by delivery in May 2019. However, as of mid-June 2019, the ship was still in the final stages of outfitting at GRSE's fitting-out jetty. It would seem likely that delivery will take place in late 2019 or early 2020.

The overall build quality of the Project 28 corvettes is generally regarded as having improved considerably over older generations of Indian-built warships. However, the two earliest ships were still

The second *Kamorta* class *Kadmatt* pictured in the early stages of assembly. Vessels No 2 and No 4 in the programme were assembled in a building berth which was then flooded up to permit 'launch'. *(Mrityunjoy Mazumdar)*

delivered with a significant amount of defects and without full testing of a significant range of weapons and systems.[6] Moreover, the project has taken far longer and cost much more to deliver than originally envisaged.

PROGRAMME DELAYS AND COST OVERRUNS

Many of the delays and, particularly, the cost overruns associated with the *Kamorta* class programme can be attributed to the relatively immature nature of the design when the project was first authorised in 2003. The design and build specification continued to evolve, with significant changes arising through to 2008. By November 2010, around 1,200 design changes had been implemented. In addition, the design incorporated many new systems and technologies whose impact could only be properly assessed late in the construction cycle. Ultimately GRSE and the Ministry of Defence agreed a substantially revised cost of INR7,852.39 crore (INR78.5bn), including INR331.27 crore (INR 3.31bn) for yard modernisation. The revised figure was agreed by the CCS in April 2012 and formed the basis of a fixed-price contract awarded to GRSE in June of that year.

As has been the case for many other Indian naval programmes, delays in modernising inadequate shipyard infrastructure have been cited as another major influence on tardy programme completion. Planned yard modernisation projects were slow to materialise and lagged behind the ships' construction schedule.

Another source of difficulties related to problems with the supply chain. For example there were delays in receiving design data from vendors of major engineering equipment such as the raft-mounted gearbox. Ongoing problems with procuring D40S shipbuilding steel from Russia had led to a decision to source steel of similar quality locally. However, obtaining the required quantity of the indigenous DMR294A equivalent from the producer – the Steel Authority of India – was not altogether straightforward. Supplies of the new steel did not start to arrive until July 2005, a key factor behind the delay in the start of construction on the lead ship.[7]

Delays resulting from the need to mature the Project 28 design meant that the lead corvette, *Kormata*, was only launched on 19 April 2010, around two years after she was due to be delivered. Moreover, it was not until 2012 that a formal contract for the class's construction was signed with GRSE. *(Mrityunjoy Mazumdar)*

Further delays were experienced with the acceptance trials of a number of items of critical equipment. In certain cases this meant that acceptance took place with changed or diluted parameters compared with the stated technical requirements.

There seem to have been particular problems with the development and supply of a number of indigenous weapons and sensors. One example was the planned point-defence missile system, which was initially slated to be produced as part of a joint project with MBDA known as Project Maitri. However, this programme was delayed and probably shelved in favour of an alternative – possibly a navalised version of the indigenous Astra air-to-air missile – under the aegis of the short-range surface-to-air missile (SRSAM) programme. As the project is still under development, the class have been completed without this capability.

The last pair of ships presented unique problems by virtue of their composite superstructures. The orders for these were placed late in the production cycle, possibly accounting for some of the gap in production between the first and second pairs. GRSE subsequently reported having to overcome several challenges installing and integrating the composite superstructure blocks and panels onto the steel hull. In spite of this, overall production times have improved slightly over those for the first two ships.

After entering the water, the Project 28 corvettes were towed to GRSE's fitting-out basin slightly higher up the Hooghly River. This busy view of the basin dates from around 2013. *Kamorta* can be seen in the final stages of fitting out alongside the quay to the left whilst *Kadmatt* (left) and *Kiltan* (right) are at earlier stages of completion in the foreground. In contrast to the two earlier ships, *Kiltan* is fitted with a superstructure manufactured of composite materials. Whilst this posed challenges in the assembly and fitting-out process, *Kiltan* was still completed more rapidly than her sisters *(GRSE)*

DESIGN DESCRIPTION

OVERVIEW

Principal technical characteristics of the Project 28 *Kamorta* class are provided in Table 3.1.2. Traditional mono-hulled ships, the class has an overall length of 109.1m and a waterline length of 102.3m. There is a maximum beam at the 'knuckle' of 14.2m and a waterline beam of 12.8m. They have a moulded depth of 8.5m to the main or weather deck (Deck 1), where moulded breadth is 13.7m. Designed draft at standard load was 3.7m, increasing to around 4.7m when the ships are fully loaded. Designed displacement was 3,170 tons when contracts were finally signed but *Kamorta* and *Kadmatt* were reportedly 3,384 and 3,490 tons at the time of delivery. The last two ships should be around 100 tons lighter.

The corvettes' hulls are constructed from indigenous DMR-249A steel. Frame spacing is 1.2m and the hull is divided by a total of thirteen transverse bulkheads. For improved seakeeping, the hull has two bilge keels separated by a fin stabiliser on either

COMPOSITE SUPERSTRUCTURE

The second pair of Project 28 corvettes incorporate a Kockums designed and built composite superstructure that is made of a 66mm thick carbon fibre reinforced plastic (CFRP) material. The same material was used in construction of the Swedish Navy's *Visby* class corvettes. The composite structure – with a length of 62.4m, a width of 14m and a height of 10.2m – comprises seven modules which are sub-divided into fourteen hull blocks.

The decks, bulkheads and stiffeners of the composite superstructure are all comprised of CFRP sandwich material. The sandwich consists of two laminate skins of fibre reinforced plastic. The skin laminates consist of vinyl ester resin reinforced with carbon fibre crimp fabric. Benefits of the use of CFRP included:

- High strength and rigidity – the material has a high resistance to explosions and shock resistance is also good.
- A reduction in structural weight – a CFRP sandwich sheet weighs only around twenty percent of that of a steel plate yet has equivalent bending stiffness. This can support greater payload carrying capabilities, higher speeds and longer ranges
- Integrated stealth qualities.

The use of the composite superstructure necessitated the installation of additional fire detection sensors for the automated fire detection system.

To install approximately ninety or so pieces of equipment, around two dozen openings were cut out of the composite superstructure as shipping routes for the equipment. These openings were then closed up.

side. The superstructure used in the first pair is of steel while the second pair have a composite superstructure to save top weight.

The main, No 1, deck has a low sheer line and extends by way of the enclosed superstructure area all the way to the helicopter flight deck at the ship's stern. There are three principal deck levels – Decks 01 to 03 – above the main deck. Deck 02 forms the base of the bridge whilst Deck 03 corresponds with the level of the bridge roof. One level above this – effectively Deck 04 – are the exposed platforms for the fore and aft fire-control directors. The enclosed foremast has yardarms and a pole mast for the ships' electronic warfare suite. The length of the superstructure, which includes the hangar and funnel stack, as well as the foremast and the main mast is about 60m and its height from the main deck to the bridge-top is a little over 8m.

Each ship has three principal decks below the main deck – Deck 2 to Deck 4. Comprising over 100 compartments, they encompass the bulk of the ships' equipment, storage and accommodation spaces. The machinery spaces stretch upwards for two deck levels from Deck 4, encompassing the bulk of the ship's central sections. Below these decks is one more deck – Deck 5 - in the fore section of the ship for the sonar dome and associated sonar equipment.

PROPULSION AND ELECTRICAL SYSTEM

The propulsion system comprises a combined diesel and diesel (CODAD) arrangement. Four Pielstick 12 PA6 STC diesel engines drive two propeller shafts. The engines are grouped in pairs in forward and aft engine rooms, with each pair connected to a gearbox that has either a single output or twin

Table 3.1.2.

KAMORTA PRINCIPAL PARTICULARS

Building Information[1]:			
Laid Down:	20 November 2006	Launched: 19 April 2010	Delivered: 12 July 2014
Builders:	Garden Reach Shipbuilders & Engineers Ltd, Kolkata		
Dimensions:			
Displacement:	c. 3,400 tons		
Overall Hull Dimensions:	109.1m x 14.2m x 3.7m. Waterline length and beam are 102.3m and 12.8m respectively.		
Equipment:			
Main Gun:	1 x 76mm OTO 76/62 gun. 2 x AK-630M CIWS. Machine guns.		
Missiles:	2 x positions for future SRSAM short-range surface-to-air missiles.		
ASW Equipment:	2 x RBU-6000 ASW rocket launchers. 2 x twin 533mm torpedo tubes.		
Other:	Non-lethal systems including 2 x LRAD.		
Countermeasures:	Sanket Mk III ESM. 2 x 'Kavach' Mod 2 decoy launchers.		
	Torpedo defence system to be fitted in due course.		
Aircraft:	Flight deck and hangars for one medium-sized helicopter.		
Principal Sensors:	'Revathi' 3D radar. Integrated IFF. Navigation radar. HUMSA-NG bow-mounted sonar.		
	TAS to be fitted in due course.		
Combat System:	CMS-28. Composite Communication System Mk III. Indian Naval Data Link (INDL) Link II Mod III		
Propulsion Systems:			
Machinery:	CODAD. 4 x Pielstick 12 PA6 STC diesels each rated at 3.9MW provide a total of 15.6MW through two shafts.		
Speed:	25 knots designed. 23.9 knots was achieved on trials. Designed endurance is 3,450 nautical miles at 18 knots.		
	.		
Other Details:			
Complement:	195 including 15 officers.		
Class:	*Kamorta* (P28), *Kadmatt* (P29), *Kiltan* (P30) & *Kavaratti* (P31).		

Notes:

1. A first steel cutting ceremony was held on 6 Aug 2005. Formal commissioning took place on 23 Aug 2014.

output mode. Each gearbox is, in turn, connected to a Wärtsilä-supplied shaftline driving a five-bladed Wärtsilä 5C10 controllable-pitch propeller. The engine and gearbox combinations are raft-mounted to minimise vibrations, with one 70-ton raft located in each engine room.

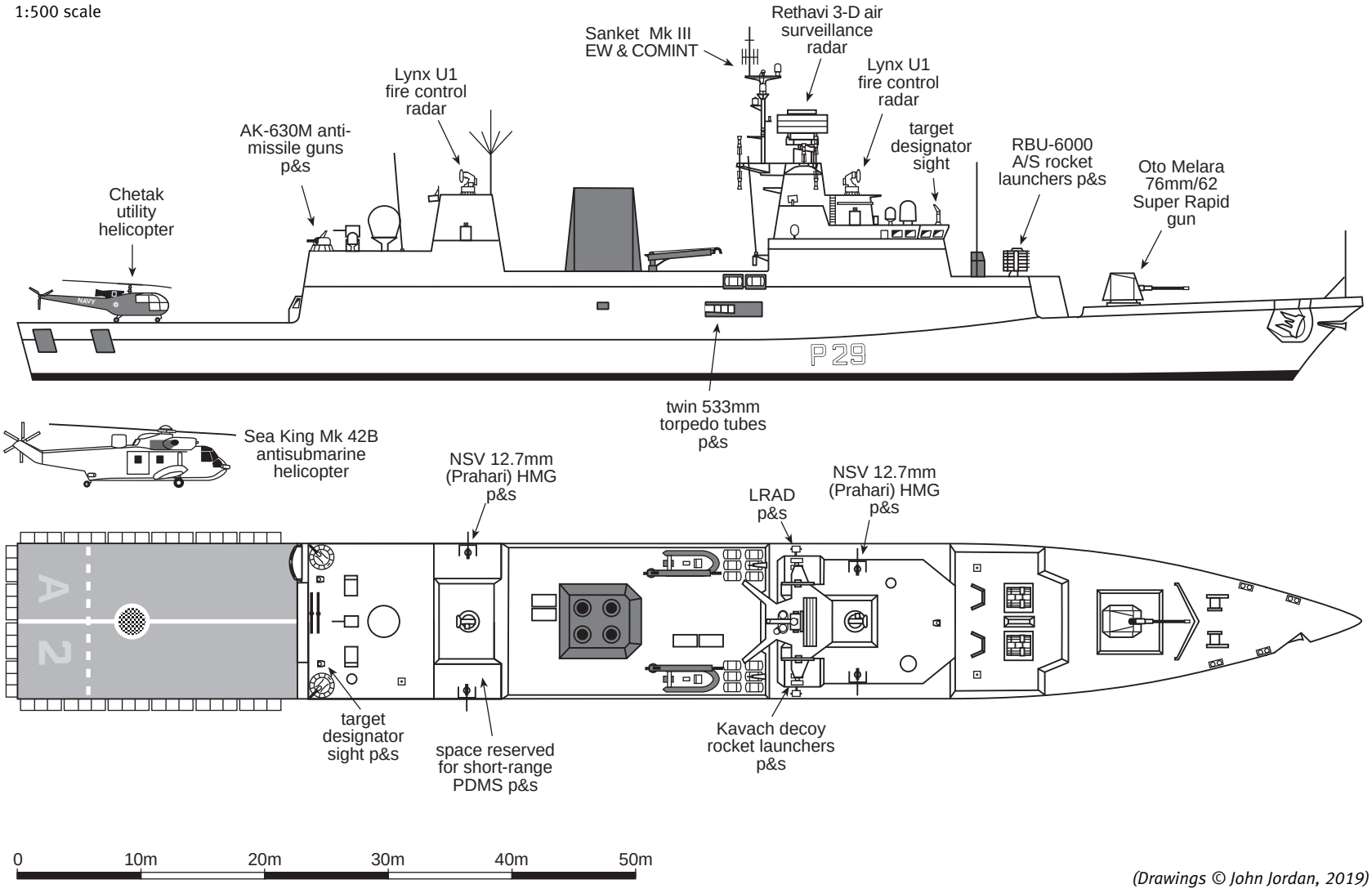
The Pielstick diesels are each rated at 3.9MW for a total power output of 15.6MW. The original build specification released in 2003 specified a maximum speed of 25 knots at an ambient temperature of 40°C. However, actual trial speeds – 23.9 knots and 22.8 knots respectively for *Kamorta* and *Kadmatt* – failed to meet this requirement due to the excess weight issues noted above. Maximum designed speed on one shaft is 18 knots and range at cruising speed of 18 knots is 3,450 nautical miles.

The ships are equipped with a 415V/50 Hz/3 phase electrical distribution system supplied by four Wärtsilä Cummins diesel generator sets. Three of these generators – one 1,000kW WCM 1000/5 and two 500kW WCM 500/5 – are located in the forward generator compartment and a single 1,000kW WCM 1000/5 generator is located in the aft compartment. There is also a smaller emergency diesel generator linked to its own emergency supply circuit.

Since around 2016, the ships' funnels have all been painted black, possibly to hide accumulations of soot from the diesel exhausts.

MACHINERY AND DAMAGE CONTROL

The propulsion and electrical systems are monitored and controlled by means of an integrated platform management system (IPMS) supplied by L3. This incorporates both an integrated bridge system and a battle damage control system. The system incorpo-



(Drawings © John Jordan, 2019)

Two photographs of a newly-completed *Kamorta* at speed. Her CODAD power plant is controlled by an L3-suppled integrated platform management system (IPMS) that integrates with bridge and damage control components. The ship is divided into four separate fire zones for damage control purposes. *(GRSE)*

rates the usual array of fibre-optic cable linked multi-function consoles and remote terminal units to allow access from various locations around the ship, making it possible to do 'anything from anywhere at any time'. The main monitoring position is a combined ship control centre and damage control headquarters located at Deck 3 level.

The integrated bridge system uses similar user interfaces to fuse data from a comprehensive suite of sensors that includes two commercial Sperry Marine navigation radars. It includes automatic radar plotting aid and electronic chart display information system (ECDIS) applications certified to the latest International Maritime Organization standards. It is likely that that the corvettes, like many other Indian Navy warships, use Transas-supplied ECDIS software. The integrated bridge system also links with the combat management system and has an onboard training module.

One interesting feature incorporated within the IPMS is a personnel location system. This uses some 40 readers and 300 transponders/tags that allow onboard personnel to be tracked and led efficiently under a wide range of conditions, especially during casualty and battle damage scenarios. It is typically used in conjunction with the platform management systems' CCTV network to help crew to respond to mission requirements.

Structurally, the ships are sub-divided into four separate fire zones for damage-control purposes. A wide range of fire protection measures includes an automated magazine firefighting system of Russian origin that encompasses the magazine spaces, gun barbettes and helicopter hangar. Nuclear, biological and chemical protection is based on independent 'citadels' provided with a total atmospheric control system. Early warning of potential toxic threats is provided by Bruker RAID S Mod 2 detectors, which identify possible breaches of the chemical, biological, radioactive and nuclear (CBRN) filter system. A ship-installed radiac system – believed to be Electronics Corporation of India's SIRS 4012 – is also installed to monitor gamma radiation in and around the vessel.

SIGNATURE MANAGEMENT SYSTEMS

The Project 28 design incorporates a comprehensive set of signature management features designed to minimise the class's observability across the radio, acoustic, thermal and electromagnetic domains.

Radar cross section (RCS) is addressed by the

An atmospheric view of *Kiltan* undertaking a night-time replenishment at sea exercise with the Royal Australian Navy's replenishment tanker *Success* on 9 April 2019. The Project 28 design's focus on physical stealth features includes the use of an inward-sloping, tumblehome hull design and an 'X' shaped superstructure cross-section, with physical protrusions limited to the minimum extent possible. *(Royal Australian Navy)*

adoption of an inward-sloping, tumblehome hull design and an 'X'-shaped superstructure cross-section using a slope of c. 9° to the vertical. The 'X' form begins where the foredeck ends and the superstructure begins and extends all the way to the hangar along the prominent knuckle line.

As previously mentioned, the main engines and gearboxes are raft-mounted to minimise vibration and noise. The 1000kW diesel generator sets are housed in acoustic enclosures to control emitted noise while other machinery and equipment is mounted on dampers and vibration isolating mounts.

Thermal signatures in the medium and far infrared (IR) wavebands are countered by the installation of IR suppression systems on the exhausts to both the diesels and main diesel generators. According to the NSTL, this serves to reduce the platform's signature by as much as ninety percent in both IR bands, significantly enhancing the design's survivability against IR-guided missile threats. The suppression systems were designed by NSTL, possibly on the basis of absorbing technology provided by Canadian-based W R Davis Engineering for the Project 17 frigate programme.

Hull magnetic signatures are reduced by using a Larsen and Toubro (L&T) supplied tri-axial degaussing system. An active shaft grounding system is also installed as protection against influence mines that sense a ship's underwater extremely low frequency electromagnetic signature.

COMBAT SYSTEMS AND SENSORS

The majority of the Project 28 design's combat systems are manufactured in India under the policy of maximising the class's indigenous content. However, several of these systems are either licence-built copies of foreign equipment or locally-developed variants of systems originally sourced from overseas.

Combat Management System: Overall control of the *Kamorta* class's weapons and sensors is provided by a CMS-28 combat management system that is believed to be an indigenised version of the largely Russian-derived CMS-17 system used in the Project 17 class frigates. Software and hardware development has been performed by the Indian Navy's Weapons and Electronics Systems Engineering Establishment (WESEE) in conjunction with appropriate external partners. The system includes at least six multi-function consoles (colour technical displays in Indian Navy jargon) in the operations room. As with similar systems the world over, CMS-28 creates an overall, up-to-date picture of the tactical situation, acting as a decision support and threat evaluation system for resource (weapons) allocation.

CMS-28 functions are supported by the Shipboard Data Network-28, a scalable ethernet-based shipboard network integrating data from various sensors and systems. Encompassing voice, video and data media, it forms the network back-

bone for combat management and external and internal communications.

Weapons safety is performed by the Ship Weapon Interlock Safety System 28 (SWISS-28), utilising software provided by a BAE/HAL joint venture in Bangalore.

A picture of *Kamorta* on exercises with the Royal Australian Navy frigate *Newcastle* in June 2017. Her stealthy design, as well as many of her weapons and sensors, are from a different era than the veteran Australian ship. Equally interestingly, many of these are of Indian manufacture.

Kadmatt pictured at the LIMA 2019 trade show, where she was displayed as evidence of India's progress in developing naval technology. She represents a major step forward in the use of indigenously-sourced material and equipment; as much as ninety percent according to some sources. However, much of the latter is still foreign or foreign-derived equipment produced under licence. *(Chris Sattler)*

Surveillance Radar: The Project 28 class corvettes are equipped with a Bharat Electronics Limited (BEL) 'Revathi' 3D radar, a naval derivative of the

INDIGENOUS CONTENT

A major priority for the Project 28 programme was to drive forward the proportion of domestically-sourced material and equipment used in the design. Just over eighty percent of each Project 28 corvette is believed to be of indigenous manufacture, although figures as high as ninety percent have been claimed by builders GRSE.[1]

The Indian Navy sometimes likes to categorise levels of indigenisation into fight, float and move categories. This forms an interesting way of assessing indigenous content in the Project 28 programme.

Float: Indigenous content is likely to be high in the 'float' category since most of the material used to build the ships, most notably the DMR-249A steel, is locally sourced and manufactured. An exception is the composite superstructure sourced from Kockums and used in the third and fourth ships of the class.

Move: The level of indigenous content is somewhat less in the 'move' category. Although most of the Project 28 corvettes' machinery has been built locally, some key equipment – for example the first pair of raft-mounted gearboxes used in *Kamorta* – has been imported.[2]

Fight: The Project 28 corvettes have a far higher indigenous content than other Indian navy warships in the 'fight' category since the majority of installed weapons and sensors have been built locally, albeit to a mix of licence-built and full Indian designs. However, some systems have been manufactured overseas, for example the sonar dome and directing gear.

Notes

1. Although not explicitly stated, it is assumed that these calculations are based on cost.

2. The gearboxes for the remaining three ships were built in India by Walchandnagar Industries limited (WIL) as part of a transfer of technology from Naval Group.

company's 'Rohini' array used by the Indian Air Force. Developed by LRDE, these radars are improvements of the establishment's central acquisition radar (3D-CAR), which is believed to have been influenced by technology obtained from Poland's PIT Radwar.[8] Operating in the 2,000–4,000MHz 'E/F' bands (US Navy 'S' band), Revathi is understood to have a range in excess of 200km and can track around 150 targets. It uses a two-axis stabilisation system developed by L&T. The radar has an integrated IFF system – IFF 1410 NV – mounted atop the planar array antenna

Anti-Air and Anti-Surface Warfare Equipment: The corvettes are fitted with a single Oto Melara 76/62 main gun in a stealthy turret in 'A' position. The guns are manufactured by Bharat Heavy Electricals Limited (BHEL) at its Haridwar plant in northern India, which has assembled around forty of these guns since 1994. The gun is used both for anti-surface and anti-air purposes.

Close-in defence against airborne targets is provided by two Russian-designed AK-630M close-in weapons systems (CIWS), which are fitted atop the hangar deck. The AK-630M guns are licence-built at the Indian Ordnance Factory Board's Gun and Shell Factory in Cossipore, Kolkata.

These guns are directed by a Bharat Electronics Ltd (BEL) supplied gunfire control system comprising two Lynx U1 or U2 fire-control directors as well as three manually-operated target designation sights (TDS). Two of the TDS – located next to the CIWS – are slaved to each of the AK-630M gun mounts while the TDS mounted atop the bridge is slaved to the main gun. The Lynx U1/U2 directors are a locally modified version of the Contraves TMX-EO system.

For force protection, several gun positions equipped with armour plating for 12.7mm NSV

This detailed bow view of *Kadmatt* shows many of her principal weapons systems and sensors. A single Oto Melara 76/62 main gun in a stealthy turret is located in 'A' position whilst two indigenously-produced variants of the Russian RBU-6000 anti-submarine rocket launcher are positioned on the superstructure deck in front of the bridge. There is a single TDS for the main gun on top of the bridge and a Lynx U1 /U2 series fire-control director on the platform behind. The The 'Revathi' 3D radar sits on top of the enclosed mast structure. To the sides of the roof structure are two armoured positions for heavy machine guns and, further aft, platforms for 'Kavach' Mod 2 decoy launchers. *(Courtesy Chris Sattler)*

This photograph of *Kadmatt*'s hangar depicts the two AK-630M CIWS, each with its own assigned TDS. There is a Lynx U1/U2 series fire-control director on the centre-line platform towards the forward end of the hangar roof. The vacant positions for short range surface-to-air missiles located to either side have been used for temporary heavy machine gun positions. Also evident is an Orbit satellite dish and various aerials associated with the BEL-supplied Composite Communication System. *(Courtesy Chris Sattler)*

machine guns as well as some light machine gun mounts have been installed. There are also two, non-lethal long range acoustic devices (LRADs) – one on each side on the bridge deck.

The surface-to-air missile system for point defence that was due to be fitted to the class has not been installed and the spaces reserved for vertical launch units on either side of the aft Lynx tracker platform remain empty. It is unclear whether the Barak 1 missile system used elsewhere in the Indian Navy will be fitted whilst the SRSAM programme previously mentioned is completed.

Anti-Submarine Warfare Equipment: Given the Project 28 class's primary anti-submarine warfare role, ASW equipment features prominently in their design.

The overall ASW system is controlled by a BEL-built IAC Mod C fire-control system, which is an integrated anti-submarine warfare system that uses a modular open system architecture and interfaces. The system is designed to perform threat analysis and compute ASW fire-control solutions, interfacing with shipboard anti-submarine weapons and torpedo countermeasures (such as expendable decoys). According to BEL, IAC Mod C can compute contact motion analysis for up to twelve active and twenty-two passive sonar targets. It is able to handle the simultaneous designation of up to four targets, generating fire-control solutions that encompass the generation of the ship's optimum course, speed and weapons release points at speeds of up to 24 knots.

The primary ASW sensor installed on the corvettes is BEL's HUMSA-NG bow-mounted sonar.[9] An advanced active/passive sonar, it is fitted to a wide range of current Indian Navy platforms, including the Project 15A destroyers and Project 17 frigates. It is believed to be able to locate and track up to eight targets simultaneously. The sonar dome and sonar directing gear are both supplied

The Project 28 class's outfit of onboard anti-submarine warfare weapons comprises two twin mounts for anti-submarine torpedoes – hidden behind the openings in the hull's central section – and the RBU-6000 rocket-launching system fitted forward. A BEL-built IAC Mod C fire-control system linked to the bow mounted sonar computes fire control solutions. However, whilst this view of *Kadmatt* shows openings underneath the helicopter flight deck for use with a TAS, neither the planned towed array nor a torpedo defence system are currently fitted. *(Courtesy Chris Sattler)*

by Tods Defence, now part of Unitech Aerospace.

Unfortunately, the planned installation of a towed-array sonar (TAS) has not yet materialised, significantly limiting the class's utility in the submarine-hunting role. The indigenous 'Nagan' TAS programme was cancelled around the turn of the decade. The Indian Navy has subsequently pursued a number of alternative options to equip its surface warships, including the procurement of Atlas Elektronik's ACTAS. However, it is not clear that this system can be installed in the Project 28 class vessels without significant modification. As of mid-2019, the three operational *Kamorta* class vessels remain without this key capability.

Primary shipboard ASW weapons are the two indigenously-produced RBU-6000 anti-submarine rocket launcher variants and two trainable, twin tube torpedo launchers for heavyweight torpedoes based on the DTA-53 design. Both items of equipment, which are produced locally by L&T, feature several detailed improvements over the original Russian designs.

The planned torpedo defence system – which was originally due to be integrated with the 'Nagan' TAS – is another item of ASW equipment that has not yet materialised. Current plans appear to be based on the installation of the NSTL-developed 'Mareech' automated torpedo defence system, which was trialled onboard two Project 16 frigates during 2014–15 but only cleared for series production in 2018. Operated on the basis of inputs from either a bow-mounted or towed-array sonar (or a combination of both), key components include a towed torpedo decoy and expendable decoys fired from ten-barrelled decoy launchers.

Aviation Facilities: The ability to operate an anti-submarine helicopter is an important part of the Project 28's ASW capabilities. The design incorporates a helicopter flight deck measuring approximately 23m by 14m and there is a hangar for a single medium-sized helicopter. The hangar is flanked by maintenance workshops and weapons stowage spaces. Flying operations are controlled from a flying control position located level with the flight deck to the port side of the hangar.

The flight deck is fitted with a helicopter traversing system based on MacTaggart Scott's 'Trigon' system manufactured by GRSE's engineering division under a technology transfer arrangement. The system is known locally as a rail-

This image of *Kamorta* taken in 2017 provides a good view of the Project 28 type's stern, including the large helicopter flight deck and single folding hangar door. The deck level below the flight deck is designated for a towed array but this equipment is not currently installed. *(Mrityunjoy Mazumdar)*

This close-up of *Kadmatt*'s foremast provides a good view of the various DF and sensor units associated with the Sanket Mk III ESM system fitted to the Project 28 corvettes. The ESM system includes a licence-built Elta ELK 7036 communications intelligence component, distinguished by the Adcock antenna arrangement at the top of the pole. Also evident is the large 'Revathi' 3D radar on top of the enclosed mast structure and – further forward atop the bridge – a Lynx U1 /U2 series fire-control director. *(Courtesy Chris Sattler)*

less auto tensioning winch wire helicopter traversing system. GRSE claims it has reached an indigenisation level of seventy-two percent with effect from the third ship, *Kiltan.* The helicopter landing grid and the folding hangar door are both supplied by L&T.

Although these ships are designed to operate Sea King helicopters, in practice a Chetak utility helicopter is usually embarked. It is unclear if the shortage of the aging fleet of Sea Kings has contributed to this practice but it represents another marked diminution of the class's operational effectiveness in its primary anti-submarine role.

Countermeasures and Electronic Warfare: Pending the addition of the planned torpedo defence system, physical countermeasures are focused on protection against anti-ship missiles. The corvettes are equipped with the 'Kavach' Mod 2 decoy launching system for this purpose. Two sets of sixteen-barrelled chaff rocket launchers are installed on prominent platforms either side of the enclosed foremast. Range is around 1,000m according to media reports. The system's launchers – and possibly the entire system – are built at the Ordnance Factory Board's Machine Tools Prototype Factory in Ambernath, near Mumbai.

Electronic support measures (ESM) capabilities are based on the Sanket Mk III ESM system. This was developed by the LRDE and built by BEL. The installation on the *Kamorta* class incorporates a licence-built Elta ELK 7036 communications intelligence component. The main external elements of the ESM system are mounted on a pole mast atop the rear of the enclosed mast. The ELK 7036 subsystem is distinguished by its Adcock antenna arrangement with four equidistant vertical elements which can be used to receive directional radio waves. There are also three dome-shaped direction finding (DF) units and two additional cylindrical DF/sensor units. Further coaxial dipole antennae are mounted on yard arms around the foremast. According to BEL, the system intercepts, analyses and identifies radar signals operating in the 'C' to 'J' frequency bands and displays the emitter(s) on an operations console in the ships' electronic warfare room.

Communications and Data Links: The Project 28 corvettes use a BEL-supplied Composite Communication System Mk III. Key sub-components encompass (i) a control and monitoring subsystem (ii) a medium frequency subsystem for telegraphy and monitoring the maritime distress

frequency (iii) a high-frequency subsystem for long-range ship-to-shore and ship-to-ship communication (iv) a VHF/UHF subsystem for medium-range ship-to-shore and ship-to-air communication and (v) a radio-actuated teletype (RATT) sub-system for teleprinter and telegraphic communication. Components suppliers include Electronics Corporation of India, L& T and Rohde & Schwarz. Externally, there are a number of 7m-long whip antennae as well as an inverted cone antenna aft of the funnel.

Satellite communications equipment includes a prominent dome atop the helicopter hangar housing an Orbit receiver. There are also two domes atop the bridge-house, including a Fleet 500 broadband antenna. The equipment forms part of the Indian Navy's Rukmani satellite communication network.

Major Indian Navy platforms are fitted with an indigenous data-link system known as Link II (Link 2), which is also referred to as Indian Naval Data Link (INDL). The version on the Kamorta class is believed to be the BEL-built Link II Mod III system. According to BEL, the system which can transmit voice, video, tactical and messaging information at a data rate of 2 Mbps, integrating directly with the combat management system.

INTO SERVICE

The three Project 28 corvettes that have been delivered to date serve with the Indian Navy's Eastern Fleet and are homeported in Visakhapatnam. Since entering service, the ships have been deployed overseas extensively as part of India's 'Look East/Act East' policy, also showcasing India's naval shipbuilding capabilities. This has included participation in international fleet reviews as far afield as Singapore and Thailand and the IMDEX and LIMA trade shows. They have taken part in just about every major exercise – national, international and multinational – involving Eastern Fleet ships. Areas of operations to date have extended throughout South East Asia and as far as Vladivostok and Guam in the Pacific.

GRSE has been marketing variants of the Project 28 to international customers, although there has been no tangible success to date. In 2016, it lost out to South Korea's Hyundai Heavy Industries for the Philippine Navy's 'Horizon 1' frigate project for two hulls despite being the lowest bidder. At the time, GRSE offered a variant that incorporated a Thales sensor and communication suite and MBDA's MM40 Exocet anti-ship missiles. It is again in the running for the Philippine Navy 'Horizon 2' corvette project for another two hulls.

Farther afield, GRSE was one of nine contenders for the Brazilian Navy's *Tamandare* corvette project. The proposal was broadly similar to that made to the Philippines but included combat systems from Israeli and Brazilian companies. The proposal failed to make a list of four finalists from which ThyssenKrupp Marine Systems' MEKO A100 design was ultimately selected in March 2019.

CONCLUSION

The Project 28 corvette programme appears to have been a mixed success. Positively, the programme has significantly advanced the Indian Navy's indigenous shipbuilding capabilities, proving local industry's ability to build state-of-the-art warships with an indigenous content of between eighty and ninety percent. The expansion of the local supply chain through advances such as, for example, the ability to produce DMR-249A steel will pay dividends for future indigenous naval construction.

These advances have come at a price. Due to unrealistic initial costings and poor project implementation, programme cost of INR7,852 crore or INR78.5bn (c. US$1.2bn or US$300m per unit) has proved more far expensive than first anticipated. Moreover, the ships have taken around double the expected 48 months to deliver. Perhaps more significantly, the corvettes have failed to meet their design specification with respect to speed and currently lack a range of mission-critical equipment. It is only once these gaps are rectified that the class will approach their full warfighting capability and it remains to be seen when this will take place.

Looking to the future, earlier talks of additional hulls – a total of twelve ships was once mooted – have now morphed into what is known as the Next Generation Corvette project. This will be a significantly larger multi-role platform that will be influenced by the Programme 17A frigates now under construction both at GRSE and Mumbai's Mazagon Dock. It will likely be a decade or more before this programme enters the construction phase.

Notes

1. For more detail on the Project 17 programme see the author's '*Shivalik* Class Frigates', *Seaforth World Naval Review 2013* (Barnsley: Seaforth Publishing 2012), pp.148–65.

2. This information is contained in *Report No.19 of 2017 of the Comptroller and Auditor General of India: Union Government (Defence Public Sector Undertakings –Ministry of Defence),* (New Delhi: Comptroller and Auditor General of India, 2017), chapter 2. The approval granted amounted to INR 3051.27 crore, encompassing an additional INR 180 crore to improve shipyard facilities. The report is available at: https://cag.gov.in/sites/default/files/audit_report_files/Report_No_19_of_2017_Compliance_audit_Union_Government_Defence_%20Defence_PSU%20_Ministry_of_Defence.pdf. It is believed the cost estimates were derived from the cost of the previous generation Project 25A Kora class corvettes. See Ajai Shulka, 'Project 28 corvettes: India to tender for composite technology for superstructure' posted to the *Broadsword* blog on 17 December 2019 at: http://ajaishukla.blogspot.com/2009/12/project-28-corvettes-india-issuing.html.

3. According to *Report No.19 of 2017 of the Comptroller and Auditor General of India,* ibid, only 'a sketchy specification' of the ship was made available to GRSE at the time the letter of intent was issued. Finalisation of system design, as well as specification of equipment, weapon and sensor fit were to be undertaken by the DND at a later date. This work was largely completed in 2006 but major modifications continued until 2008.

4. All the Project 28 corvettes are named after former 'Petya' class corvettes.

5. The cause is believed to have been a failure of the steering gear control system, although some reports also refer to propulsion problems.

6. *Report No.19 of 2017 of the Comptroller and Auditor General of India,* op cit.

7. Confusingly, different audit reports give different dates for the first receipt of indigenous DMR294A steel. The 2005 date is the most convincing as it coincides with first steel cutting on the lead ship.

8. The Electronics and Radar Development Establishment (LRDE) is a laboratory of India's Defence Research & Development Organization (DRDO). The 3D-CAR family of radar systems are believed to be based on PIT Radwar's TRS-19.

9. HUMSA stands for hull-mounted sonar advanced. HUMSA-NG is an upgrade of the previous HUMSA system and is India's third generation indigenous sonar.

TIDESPRING
LONDON
IMO9655535
A136

3.2 SIGNIFICANT SHIPS

Author:
Conrad Waters

'TIDE' CLASS FLEET TANKERS & HNoMS MAUD

Aegir® Type Fleet Support Ships

On 1 January 2017 the United Kingdom's Ministry of Defence (MOD) issued a bullish press release heralding 2017 as the 'Year of the Navy'.[1] Much was made of the imminent start of sea trials of the new aircraft carrier *Queen Elizabeth*, subsequently commissioned into the fleet at a ceremony at Portsmouth attended by HM The Queen on 7 December of that year. Buried deeper in the MOD's announcement was the news that the first of four 'Tide' class fleet tankers, *Tidespring*, would arrive from her South Korean builders in the spring to undergo final outfitting. A dedication ceremony on 27 November 2017, also held at Portsmouth, marked her official entry into operational Royal Fleet Auxiliary (RFA) service.[2] Although *Tidespring*'s arrival was a much lower-key affair than that of the new *Queen Elizabeth*, the capabilities she brings are arguably just as important for the future Royal Navy fleet.

Left: The lead 'Tide' class fleet tanker *Tidespring* pictured in Carrick Roads off Falmouth on completion of her delivery voyage from South Korea. The new 'Tide' class – based on the BMT Defence Services Aegir® family of designs – are crucial to the British Naval Service's future capabilities. *(Crown Copyright 2017)*

The availability of effective replenishment at sea (RAS) facilities is a vital but often overlooked element of oceanic 'blue water' naval operations.[3] Modern warships often undertake global missions without the assistance of accompanying support vessels in peacetime conditions. However, they are heavily reliant on friendly harbours for refuelling and provisioning. Wartime deployment is a much more challenging matter: the requirement for fuel, stores and ammunition is likely to be higher and port facilities might be unavailable. Sustaining carrier operations places particularly heavy demands on sea-based replenishment, given potentially huge expenditure of jet fuel and air-launched munitions. The much greater strike capacity inherent in the *Queen Elizabeth* class carriers compared with their immediate predecessors of the *Invincible* class is particularly pertinent in this regard.[4]

The provision of suitable support vessels to provide the required replenishment facilities represents another challenge. Constructing such large ships to a bespoke design can be an expensive proposition; a particular issue for the British MOD at the time the 'Tides' were conceived given it was also struggling to fund assembly of the new aircraft carriers. However, the alternative of converting an existing merchant ship for naval service also poses problems. Use of the BMT Defence Services Ltd consultancy's Aegir® concept for 'Tide' class construction has been an interesting solution to this problem, essentially involving the evolution of a mercantile design to meet a specific naval requirement. Moreover, the adaptation of the Aegir design family for a rather different requirement in the form of the Royal Norwegian Navy's logistic support vessel *Maud* suggests the approach has wider application.

PROJECT ORIGINS

The 'Tide' class fleet tankers can trace their origins to studies around the turn of the Millennium to examine the British Armed Forces' future replenishment and floating logistical support requirements. By 2002 these studies had evolved into a Military Afloat Reach and Sustainability (MARS) project.

This aimed to replace a number of aging RFA vessels whilst providing enhanced capacity to support the increased focus on expeditionary warfare that emerged from the 1998 Strategic Defence Review (SDR). More specifically, MARS was designed to support three types of maritime task group focused on (i) carrier strike, (ii) littoral manoeuvre (i.e. amphibious warfare), and (iii) maritime security. Although it was acknowledged that the precise demands of each of these groups would differ, it was believed that all would require:

- **Bulk consumables:** Fuel and potable water transferred by hose.
- **Non-bulk consumables:** Solid cargo such as food, ammunition and general stores transferred in unit loads.
- **Forward aviation support:** The provision of helicopter basing and operating facilities to increase task group flexibility.

By 2005 it had been determined that these requirements could be met by three basic types of ship.[5] These were:

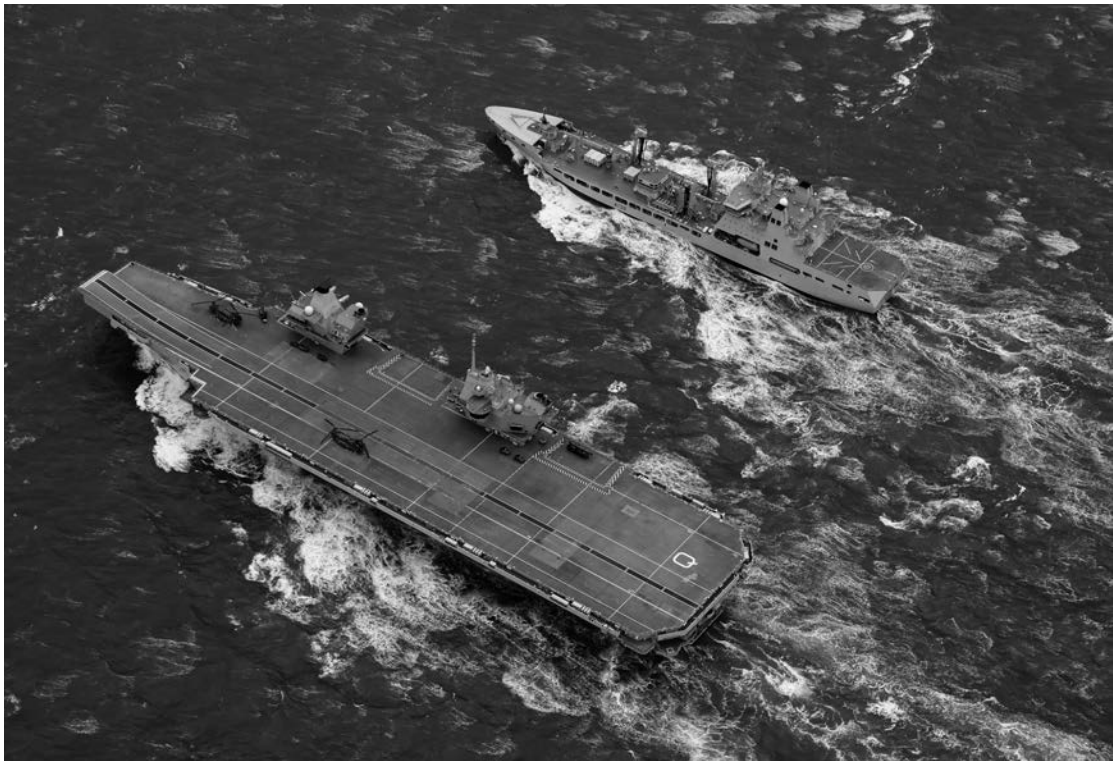
- **Fleet Tankers:** Providing bulk consumables and forward aviation support for all task groups plus very limited non-bulk consumables for small maritime security groups.
- **Fleet Solid Support Ships:** Providing non-bulk consumables and forward aviation support, principally for carrier strike groups.
- **Joint Sea-Based Logistics Ships:** Providing non-bulk consumables and forward aviation support, principally for littoral manoeuvre groups.

Contemporary reports suggested that it was envisaged a total of eleven ships would be acquired under the MARS project. These were (i) five general purpose fleet tankers and a sixth optimised for carrier strike, (ii) two fleet solid support ships, and (iii) three joint sea-based logistic ships. Deliveries of the new vessels were scheduled to take place between 2011 and 2021. In general terms, the tankers were accorded priority within the broader programme. This reflected the desirability of replacing existing tankers that were not compliant with international pollution control regulations.

MARS achieved approval for its 'initial gate' assessment phase in July 2005. The initial plan was to deliver the entire project in an alliance with a lead contractor or integrator. However, severe cost pressures and a need to prioritise the fleet tanker element of the programme resulted in the project being restructured into its discrete components at the end of 2007. Under this revised strategy, the acquisition of the fleet tankers – now often referred to as the 'MARS tankers' – was taken forward as a separate competition.[6]

The new competitive process was initiated in December 2007. In line with the 2005 Defence Industrial Strategy and the pending focus of British shipbuilders on *Queen Elizabeth* class carriers construction, the programme was opened up to international bidders. This resulted in four groups – Fincantieri of Italy, Hyundai Heavy Industries (HHI) of South Korea, Navantia of Spain and a consortium of BAE Systems, BMT and South Korea's Daewoo Shipbuilding & Marine Engineering (DSME) – being shortlisted for the contract in May 2008. None of these groups were proposing to build the ships in the United Kingdom.[7]

Despite this early progress, budgetary constraints again raised their head and the competition was cancelled following the MOD's examination of its future equipment programme in late 2008. A new international competition for the tankers was launched in October 2009, the requirement being reduced from six to four ships as a result of the 2010 Strategic Defence & Security Review. Six companies, including Britain's A&P Group, initially qualified for the competition but only three – DSME, Fincantieri and HHI – decided to submit final bids. Final, 'main gate' approval to proceed with acquisition was obtained in January 2012, with DSME being named as preferred bidder in February of that year. A contract for the four ships valued at £452m (c. US$575m) was signed the following month. Around £150m more was to be spent in the UK: £90m on equipment, support and design services, with £60m for post-completion customisation and trials. In June 2012, the names *Tidespring*, *Tiderace*, *Tidesurge* and *Tideforce* were approved for the new class.



Tidespring pictured replenishing the new aircraft carrier *Queen Elizabeth* in June 2018. The MARS fleet tanker requirement was heavily influenced by the replenishment capabilities needed to support the Royal Navy's return to strike carrier operations. *(Crown Copyright 2018)*

THE AEGIR DESIGN CONCEPT

Although the contract for the 'Tide' class fleet tankers was allocated to a South Korean company, the actual design used was provided by the British consultancy BMT Defence Services. Doubtless influenced by the developing MARS requirement, it had started to analyse the likely market for a new design of replenishment vessel during 2004. The immediate post-Cold War period had seen a reduction in construction of new logistic support vessels. Many of the aging ships still in service failed to comply with the more stringent environmental regulations – particularly the phasing-out of single-hulled tankers – that resulted from the US Oil Pollution Act of 1990 and revisions to the International Maritime Organization's MARPOL 73/78 regulations.[8] This created an opportunity. BMT also recognised that the hiatus in orders during this period had resulted in naval auxiliary design practices falling behind developments in the commercial market.

In 2005, BMT reached an agreement with Norway's Skipskonsulent to use features contained in their state-of-the-art Baltic type product tankers as the basis for a new family of logistic support ship designs. The design family was named Aegir after the Norse god of the sea and four concepts were initially produced. Three were scalable versions of a fleet tanker design covering the 10,000-ton (Aegir 10), 18,000-ton (Aegir 18) and 26,000-ton (Aegir 26) deadweight sizes. The fourth was a multi-commodity replenishment oiler, the Aegir 18R. This was based on the Aegir 18 hull but had an extended superstructure and swapped the aft-most fuel tanks for a cargo hold.

All of the Aegir concepts incorporated a modern double hull and efficient twin-skeg hull-form. Twin screw designs have become increasingly popular in commercial tanker construction in recent years. They improve propulsive efficiency through dividing installed power between two plants and provide redundancy if one of the propulsion lines becomes disabled. From a naval perspective, the arrangement improves survivability and increases the margin of safety during potentially hazardous RAS evolutions. The twin-skeg form has the advantage of being both highly manoeuvrable and directionally stable, characteristics that have subsequently been demonstrated in the sea trials of the ships built to Aegir designs.[9] Although the hull-form is similar for all Aegir types, hull lines are refined to suit the speed

A BMT graphic of their Aegir family of designs, which initially comprised Aegir 10, Aegir 18 and Aegir 26 replenishment tanker concepts as well a multi-product replenishment ship able to supply both liquid and dry stores. The RFA's 'Tide' class fleet tankers were derived from the Aegir 26 concept. *(BMT Defence Services)*

The original Aegir family of designs included a multi-commodity replenishment oiler with a significant capacity for transporting solid stores designated the Aegir 18R. This concept was used in significantly modified form for the Royal Norwegian Navy's logistic support vessel *Maud*, pictured in graphic form here. *(BMT Defence Services)*

The four 'Tide' class fleet tankers were built at DSME's giant Okpo shipyard in South Korea. This picture shows the early stages of integration of the prefabricated steel blocks for *Tideforce*, the final member of the class, on 3 August 2016. Her keel had been laid just one week earlier. *(Courtesy Shaun Jones)*

Just under two months later, on 21 September 2016, *Tideforce*'s hull is evidently already beginning to take shape. The huge dry dock is designed to support the construction of several ships simultaneously, resulting in ships being floated up several times as neighbouring vessels are released for fitting out. *(Courtesy Shaun Jones)*

profile and draught required for specific ship usage. BMT are understood to have studied Aegir variants that offer speeds between 15 and 25 knots.

Provision of a safe and effective RAS capability is clearly a fundamental focus of the overall Aegir family. The original concepts provided between two and four fluid replenishment stations dependent on variant as well as an additional stern refuelling rig. They were also equipped with a helicopter flight deck to assist vertical replenishment (VERTREP) operations and the larger Aegir 18 and Aegir 26 designs were equipped with a hangar. The cost-effective provision of helicopter facilities has always been a difficulty in the conversion of commercial tankers to naval roles due to lack of suitable space aft of the superstructure. This has been one argument BMT has deployed in support of the benefits of new construction over mercantile conversions to meet logistic support vessel requirements.[10]

The Aegir design was developed both to Lloyd's Register naval ship rules (supplemented by commercial tanker rules) and DNV classification rules for naval support vessels. However, the rules of any society belonging to the International Association of Classification Societies (ICAS) could be adopted. BMT's market niche as a leading naval design house means that it is able to work with a wide range of shipyards. Whilst the success achieved to date by Aegir has been closely associated with collaboration with DSME, one of BMT's key differentiators is its ability to collaborate with a range of facilities to provide designs tailored to meet individual customer requirements.

The design used for the 'Tide' class was derived from the Aegir 26 concept but with significant modification to meet specific RFA requirements. As explained by Simon Jones, Chief Naval Architect at BMT Defence & Security, the initial Aegir concepts were targeted to achieve low costs through the adoption of commercial stability standards in combination with naval fire and damage control systems. However, the 'Tides' – as well as Norway's *Maud* – incorporated a much higher level of survivability. This included the use of naval damage stability standards and naval features for vulnera-

bility reduction, extending to the inclusion of chemical, biological, radiological and nuclear (CBRN) protection systems.

CONSTRUCTION AND DELIVERY

The four 'Tide' class fleet tankers were built at DSME's giant Okpo shipyard in the south-eastern city of Geoje in the Republic of Korea. A steel cutting ceremony for the first ship, *Tidespring*, was held on 24 June 2014. Keel laying followed on 22 December of that year when Block 20A, the amidships cargo section, was craned into position in DSME's No 2 Dock. The tanker was floated out of its building dock for a final time on 25 April 2015 prior to a formal naming ceremony on 7 October. The efficiency of the South Korean yard is reflected in the fact that the time from first steel cutting to naming was just 470 days. By the end of 2015, work was underway on all four members of the class.

Unfortunately, the good rate of progress achieved in the early stages of construction was not maintained during setting to work and delivery, with scheduled dates for deliveries progressively pushed back. Possibly reflecting sensitivities about overseas build, the MOD's Defence Equipment & Support (DE&S) agency were tight-lipped about the reasons for the delay, although a Parliamentary question revealed that there had been problems both with detailed elements of the electrical design and satisfactory installation of the extensive multi-cable transit insulation.[11] Growing financial problems at DSME, which were eventually to result in wholesale financial restructuring and likely takeover by competitor HHI, may not have helped the situation.

The problems were reflected in the lengthy trials period undertaken by the lead ship. Although *Tidespring* commenced sea trials in March 2016, it was not until 12 January 2017 that she was accepted from the builders by commanding officer Captain Shaun Jones OBE RFA. Sailing via the Pacific Ocean and Panama Canal, she arrived in British waters at the end of March. She then docked at A&P's Falmouth yard for post-construction customisation, where work was completed in August 2017. Capability assessment trials and work up –

The second of *Tiderforce*'s twin shafts being manoeuvred into position on 25 September 2016. The photograph shows the twin-skeg shaft arrangement that is an important feature of all the AEGIR family of designs. *(Courtesy Shaun Jones)*

Tiderace being towed out of dry dock on 28 November 2015 to allow final fitting out to commence. Although early progress with construction of the class was rapid, problems with detailed electrical design and cable conduit installation were to delay the ships' delivery. *(Courtesy Shaun Jones)*

including a first RAS with the fleet tanker *Wave Knight* – preceded the 27 November dedication ceremony referenced in the opening remarks. Entry into service had been delayed some 13 months from the initial October 2016 expectation set when the build contract was first awarded in 2012.[12]

Acceptance of the remaining 'Tides' took place at five- to six-month intervals from that of the lead ship. Whilst the programme had inevitably been set back by the earlier problems, delays dropped quickly with the follow-on hulls as DSME learned rapidly from early experience. As of early 2017, the MOD anticipated all four ships would be in service by the end of 2018, as initially planned. Whilst this expectation was not ultimately realised, the third ship, *Tidesurge*, was dedicated in February 2019 and the final vessel, *Tideforce*, is expected to be operational before the end of the year.

DESIGN DESCRIPTION

Overview: The 'Tide' class's design was essentially driven by a set of key user requirements or performance measures that are summarised in the following paragraph. In turn, these performance measures were inevitably driven by what was likely to be the class's most arduous mission, viz. the ability to transport and transfer whilst underway sufficient quantities of liquid stores to sustain carrier strike group operations on a global basis. It seems likely that some compromises were made to these requirements for reasons of economy. Notably, the maximum sustained sea speed requirement of 15 knots looks low in the context of a fast-moving carrier group. However, the cost of achieving a meaningful improvement could well have been disproportionate.

Table 3.2.1.

TIDESPRING (A136) PRINCIPAL PARTICULARS

Building Information:	
Laid Down:	24 June 2014 Launched: 25 April 2015[1] Delivered: 12 January 2017[2]
Builders:	Daewoo Shipbuilding & Marine Engineering, Okpo, South Korea. Final customisation by A& P Group's Falmouth UK yard.
Dimensions:	
Displacement:	39,000 tons full load.
Overall Hull Dimensions:	200.9m x 28.6m x 10.0m. Length between perpendiculars is 185.1m.
Equipment:	
Armament:	Fitted for: 2 x Phalanx 1B CIWS. 2 x DS30M 30mm Automated Small Calibre Guns. Light machine guns.
Aircraft:	Flight deck and hangar for 1 x heavy helicopter.
Countermeasures:	Fitted for systems likely to include: Outfit UAT RESM; launchers for Outfit DLF and Outfit DLH decoys; and SSTD.
Sensors:	3 x Kelvin Hughes Sharpeye series radars.
Communications:	Leonardo integrated communications system, including MF, HF, VHF and UHF radio and satellite links.
Cargo Capacity:	19,000 metric tonnes of F76 marine diesel and F44 aviation fuel. 1,300 metric tonnes of potable water. 8 x TEU containers.
RAS & Handling Equipment:	3 x Bosch Rexroth RAS rigs (2 x starboard; 1 x port). Stern reel. 2 x 10-tonne Pellegrini Marine Equipment deck cranes.
Propulsion Systems:	
Machinery:	CODLOD Hybrid Propulsion. 2 x 7.2MW Wärtsilä L46F series main diesels or 2 x GE hybrid machines powered by 2 x 2.5MW Wärtsilä generators driving twin shaftlines via two Renk reduction gearboxes. 1 x 2MW ZF Marine retractable azimuthing bow thruster.
Speed:	Sustained speed of 15 knots in Sea State 6. Speeds approaching 20 knots reported on trials. Endurance in excess of 8,000 nautical miles.
Other Details:	
Complement:	64 core crew. Accommodation for a total of 109 personnel.
Class:	Four ships: *Tidespring* (A136), *Tiderace* (A137), *Tidesurge* (A138) & *Tideforce* (A139)

Notes:

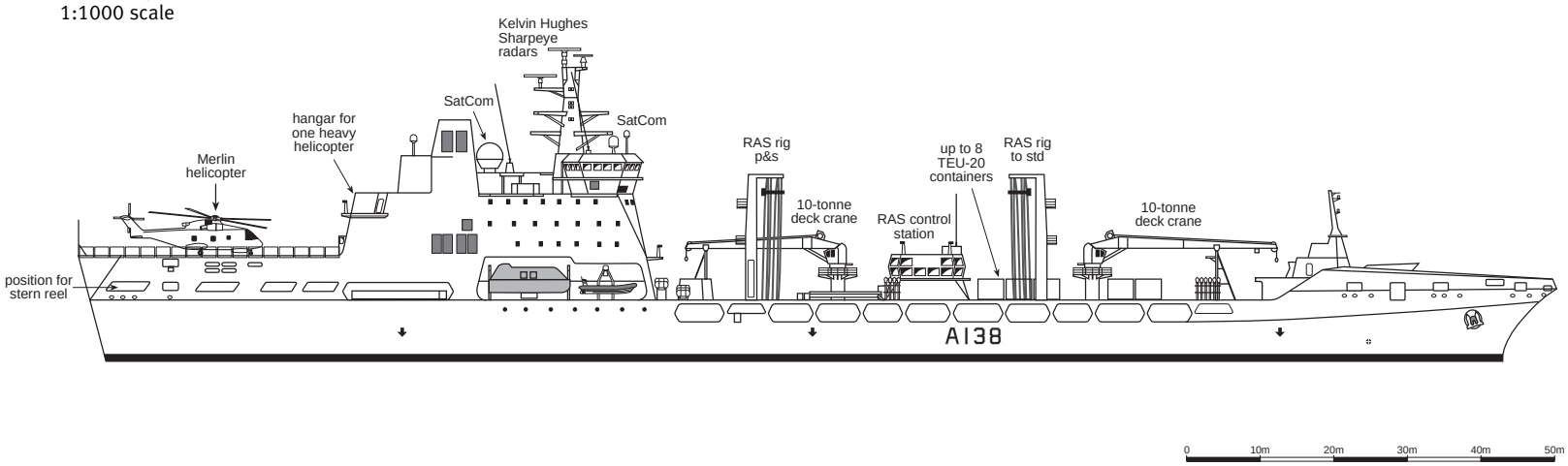
1. Date of final float-out. Naming was on 7 October 2015.

2. Ship was subsequently 'customised' at A & P Group Falmouth between April and August 2017. Dedication ceremony marking entry into the operational fleet occurred on 27 November 2017.

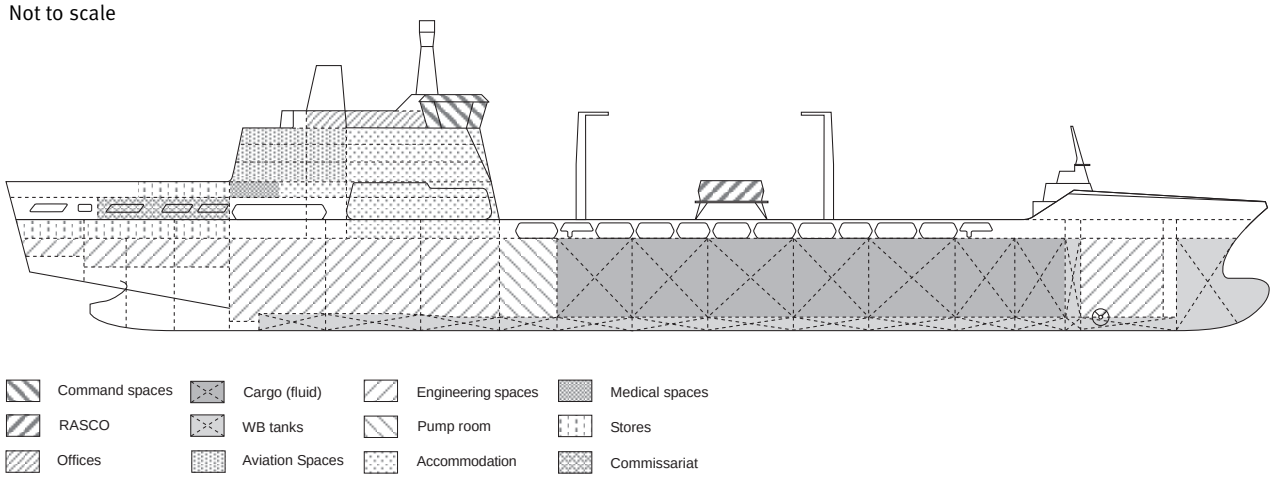
'TIDE' CLASS: PERFORMANCE MEASURES

1. Logistics – Cargo Capacity: The platform shall store 19,000m³ of useable Class II fuel.
2. Logistics – Cargo Embarkation: The platform shall embark cargo Bulk Logistics Materiel in accordance with Oil Companies International Marine Forum Publication Recommendations for Oil Tanker Manifolds and Associated Equipment 4th Edition 1991.
3. Equipment – Replenishment at Sea Capability: The platform shall deliver Bulk Logistics Materiel whilst underway and making way at 12 knots through the water.
4. Logistics – Replenishment Tempo: The platform shall deliver Bulk Logistics Materiel to 3 exchange points concurrently.
5. Doctrine – Platform Speed: The platform shall propel itself at an Upper Sustained Speed of 15 knots.
6. Doctrine – Platform Endurance: The platform shall have an endurance of 7,000 nautical miles at a sustained speed of 15 knots.
7. Doctrine – Platform Equipment Performance: The platform shall perform Core MARS Tanker functions in sea temperatures up to 38°C.
8. Doctrine – Survivability: The platform shall enable Above Water Warfare self defence.
9. Information – Computer Systems Information Interoperability: The platform shall exchange information in accordance with MoD CIS policy as recorded in the JP 600 series of Directions.
10. Doctrine – Physical Interoperability: The MARS system shall provide Logistics sustainment to UK/US and NATO Military operations.
11. Logistics – Aviation: The platform shall conduct

Tidesurge (2019)
1:1000 scale



General Arrangement
Not to scale



(Drawings © John Jordan, 2019)

the launch and recovery of rotorcraft (Aircraft Types Merlin Mk 1 or Mk 2, Surface Combatant Maritime Rotorcraft & Chinook).

Key characteristics of *Tidespring* and her sisters are set out in Table 3.2.1. The 'Tide' class are relatively large vessels by European standards with a full load displacement of some 39,000 tons. Most European replenishment vessels are multi-product replenishment oilers that have a significant solid stores capacity in addition to their ability to ship bulk (liquid) consumables. By contrast, the 'Tides' place a much greater focus on bulk stores and have only a limited ability to ship solid cargo. This requirement will be largely met by the proposed fleet solid support ships. Their closest comparators are probably the US Navy's civilian-manned *Henry J. Kaiser* (T-AO-187) replenishment oilers. These have a broadly similar size and liquid replenishment capacity as the 'Tides', albeit with a somewhat greater capacity for non-bulk consumables.

Structure: The 'Tide' class has a length between perpendiculars of 185.1m and an overall length of 200.9m. Moulded breadth is 28.6m and design draught 10m. The hull is longitudinally subdivided into sixteen separate watertight sections designated 'A' to 'R' (there is no 'I' or 'O' in Royal Navy nomenclature to avoid confusion with '1' and '0') by transverse bulkheads running from the keel at least as high as 1 Deck (Main Deck) level. This is located in line with the tops of the tanks and is also the damage control deck. There are three lower deck levels – 2 Deck (the upper platform deck, approximating to the waterline), 3 Deck (the lower platform deck) and 4 Deck (equating to the ship's keel). Moving upwards from the Main Deck are eight further decks numbered from 01 to 08. Of these, 01 Deck (the Upper Deck) can be regarded as the principal weather deck, 03 Deck is at the level of the flight deck and 07 Deck forms the floor of the bridge.

The ships' basic configuration follows that of a typical oil tanker. The two foremost sections are largely occupied by the ship's bow thruster and auxiliary machinery compartments. The next seven sections – 'C' to 'J' – comprise around 40 percent of the ships' total length and contain the storage tanks. Those in the first two sections comprise single large tanks that run the full breadth of the ship to the ballast tanks in the double hull. The remaining sections are each split longitudinally into three separate tanks for seventeen tanks in total. All the tanks occupy the entire height of the hull from the main

On completion of their delivery voyages, the 'Tides' were taken in hand for installation of sensitive military equipment under a 'customisation' process carried out by A&P Group's yard at Falmouth, where *Tidespring* is pictured on 2 April 2017. The pictures provide a good perspective of the class's overall size – at 39,000 tons full load displacement they are relatively large ships by European replenishment vessel standards. Overall configuration is broadly similar to a normal oil tanker, although the command and accommodation block, incorporating the helicopter hangar, is larger than would typically be found on a commercial vessel.
(Crown Copyright 2017)

deck to the double bottom. Above them is a broad, enclosed 'tunnel' for pipes and cables that runs below the upper deck from 'C' section as far aft as 'K' section. The principal replenishment equipment is fitted to the upper deck.

The remainder of the ship is taken up by the main machinery, command and accommodation block. The propulsive machinery is split between forward and aft engine rooms for reasons of survivability. These occupy, respectively, 'M' and 'N' sections; each extends two deck levels from the double bottom. The higher decks are largely occupied by a mixture of accommodation, offices and stowage

A close-up of *Tidespring's* aft starboard RAS rig showing a twin 7in hose being manoeuvred into position. The starboard RAS stations are specifically designed for refuelling the *Queen Elizabeth* class aircraft carriers, which are fitted with twin fuelling reception points. *(Crown Copyright 2017)*

spaces, as well as the considerable space required for the ship's embarked helicopter and the command areas focused around the bridge.

Replenishment Capabilities: The whole *raison d'être* for *Tidespring* and her sisters is the RAS capabilities that the class provides. The total capacity of the seventeen tanks amounts to 19,000 metric tonnes of F76 marine diesel and F44 aviation fuel, as well as an additional 1,300 metric tonnes of potable water. Differing proportions of F76 and F44 can be stored dependent on mission. The fuel is pumped to the RAS stations by a network of pipes, with inert nitrogen manufactured onboard used to fill the tank voids as fuel is issued.

The 'Tides' are designed with three main RAS stations equipped with electrically-operated rigs supplied by Bosch Rexroth. Two on the starboard side are specifically configured to supply bulk commodities to the *Queen Elizabeth* class aircraft carriers and are each fitted with twin 7in hoses. These essentially interface with reception points located on the carriers' port side. The third RAS position is located on the port side in line with the aftermost starboard rig and permits simultaneous abeam replenishment.[13] There is also an additional stern reel fitted below the helicopter deck to allow replenishment astern. RAS operations are coordinated from a control position (RASCO) located between the forward and aft RAS positions. Transfers can take place in conditions up to Sea State 6, although risk assessments and operational requirements take priority on a case by case basis.

Solid stores capacity is limited to positions for up to eight 20ft equivalent unit (TEU) containers, four of which can be refrigerated. Containers can be loaded by means of twin Pellegrini Marine Equipment 10-ton capacity cranes. There are also two moveable high points for reception that are combined with the port and aft starboard RAS stations. Distribution of solid stores will normally be undertaken by VETREP using the embarked helicopter.

Propulsion, Power and Control: The 'Tide' class design incorporates a hybrid combined diesel electric or diesel (CODLOD) propulsion system serving twin Schottel-supplied shaftlines and controllable pitch propellers. Each shaft is powered by either a GE-supplied hybrid machine or by a more powerful 7.2MW Wärtsilä L46F diesel through a Renk reduc-

The retractable bow thruster located in the forward hull of the 'Tide' class is provided with its own generator, providing a 'get me home' capability if the main propulsion system is disabled. *(Courtesy Shaun Jones)*

The machinery control room onboard *Tidespring*, showing the multifunction consoles used to display and manage the information provided by the ship's integrated platform management system. The facility also serves as the ship's damage control headquarters, allowing a swift, centralised response to potential hazards. *(Courtesy Shaun Jones)*

tion gearbox located in the forward (starboard unit) or aft (port unit) engine rooms. For low-speed operation, the hybrid machines are used as electric motors. They draw energy via a 690V switchboard from two 2.5MW Wärtsilä diesel generators – one located in each engine room – that are also used to provide electricity for shipboard 'hotel' services. If higher speeds are required, recourse is made to the main diesels. The specified design speed was exceeded on sea trials, with a maximum speed in the region of 20 knots being achieved.

When not being used as motors, the hybrid machines can be used in conjunction with the main engines in their alternative role as electrical generators. In this mode, they can either replace or supplement the principal diesel generators in supplying hotel services. This flexibility can, for example, increase overall fuel efficiency or help meet peak demand for electrical power, notably when energy-intensive RAS equipment is being used.

The 'Tides' are also equipped with a retractable azimuthing bow thruster provided by ZF Marine. As well as helping low-speed manoeuvrability, this is equipped with its own generator and can provide emergency propulsion in the event of severe damage to the main machinery in the aft end of the ship. The twin rudders provide excellent manoeuvrability at higher speeds.

The power and propulsion system is monitored and controlled by an integrated platform management system (IPMS) provided by Essex-based Servowatch Systems, part of the Indian Larsen & Tubro conglomerate. It is based around a dual fibre ethernet ring network using distributed processing to remove the need for a central server. As well as handling propulsion and power generation systems, the IPMS controls auxiliary and cargo-handling equipment and provides both damage control and on-board training functionality. It also interfaces with each ship's network of over fifty CCTV cameras to provide images that can be displayed on any of the multifunction IPMS workstations. The principal monitoring station is the machinery control room (MCR) located at main deck level which also functions as the principal damage control headquarters (HQ1).

The 'Tides' are controlled and navigated from the bridge through the IPMS with the assistance of an integrated bridge system supplied by Kelvin Hughes. The system collates information gathered by a suite of three of the company's SharpEye radars and a range of third party equipment. This is accessed and controlled by means of a number of console mounted Kelvin Hughes Naval MantaDigital displays. The radar suite covers the E/F (US Navy S) and I (US Navy X) bands and supports helicopter control as well as navigation functions. Standard manning at sea is one officer of the watch and two ratings. This is increased incrementally for operational evolutions.

The communications system used in the class was contracted with the former Selex ES, now merged into Italian parent Leonardo. It manages both internal and external communications across a range of media, including external MF, HF, VHF and UHF radio and commercial satellite links.

Survivability and Armament: Although not front-line warships, the 'Tides' are clearly high value units. Accordingly, a significant amount of thought has gone into their survivability and protection. Most visually apparent is the emphasis on stealth seen in most modern naval vessels, as evidenced by the non-boxlike superstructure and deckhouses that seek to present as few reflective surfaces as possible. This focus extends to the angular nature of the RAS masts and the placement of as much equipment as possible away from the open decks. Less apparent are measures to reduce infra-red signature, particularly emissions from the ships' funnels. This is achieved by use of a 'cheese grater', a large tube with slots in the sides that sits within the uptakes. The system blows exhaust gases up through its centre whilst drawing cooler, ambient air through the slits thereby – in conjunction with insulation – reducing the heat of the surrounding metalwork. Steps have also been taken to reduce acoustic signature, aided by the possibility of using electric drive for lower-speed operations.[14]

Physically, the 'Tides' are divided into four main damage control zones monitored primarily from the MCR/HQ 1 by the IPMS. The IPMS interfaces with various damage control systems such as the fixed fire protection equipment, allowing a swift and automated response to potential hazards. Survivability measures also encompass the provision of nuclear biological and chemical (NBC) protection, including the availability of a pre-wetting system and gas-tight 'citadel' arrangements. The

An impressive night-time view of the second 'Tide', *Tiderace*, in floating dock in Korea in October 2016, shortly before she was named. The picture gives a good impression of the stealth features incorporated into her design, as particularly evidenced by the shaped superstructure block and deckhouses that aim to present as few reflective surfaces as possible. The large hangar and flight deck aft allows the embarkation of a helicopter for both VERTREP and defensive purposes. *(Courtesy Shaun Jones)*

The 'Tide' class provide high-quality accommodation for their crews, with most personnel enjoying single berths with en-suite facilities. This picture shows a Senior Rating's cabin. *(Courtesy Shaun Jones)*

A fully enclosed Harding lifeboat being subject to a test launch. The 'Tide' class fleet tankers are equipped with two of these lifeboats, each one of which can accommodate the entire ship's crew. *(Courtesy Shaun Jones)*

considerable redundancy inherent in the power and propulsion system that has already been described extends to other key equipment. Some reports suggest that limited amounts of ballistic protection (i.e. armour) has been fitted to protect key positions.

Provision of armament is largely on the 'fitted for but not with' principle. Two positions for Phalanx Block 1B close-in weapons systems located forward and aft give 360° protection against missile and asymmetric threats. These are supplemented by two positions for 30mm DS30M Mk 2 automated small-calibre guns to the sides of the aft end of the hangar roof and additional locations for light weapons.[15] Little information has been released about provision for electronic warfare and photographic evidence suggests little if any equipment has been installed to date. It seems reasonable to assume that a full outfit would include launchers for Outfit DLH/Siren radiating and Outfit DLF passive decoys as well as Ultra Electronics' Surface Ship Torpedo Defence (SSTD) system and Thales' Outfit UAT RESM radar electronic support measures.

The provision of helicopter facilities is not only valuable for VERTREP evolutions but also allows for the embarkation of anti-submarine or anti-surface warfare helicopters if the requirement arises. The ship's hangar is spacious enough to house a single Merlin-sized helicopter and a larger Chinook can land on the flight deck. There are magazine facilities for helicopter-deployed weapons, including lightweight torpedoes.

Other Key Features: The 'Tide' class provides total accommodation for 109 crew members in cabins located from the main deck upwards in the forward part of the superstructure. The majority of cabins are single berth with en-suite accommodation, the latter shared between two cabins for junior rates. There are some twin cabins for embarked Royal Navy junior personnel. Cabin fittings are of a high standard, with furniture constructed with a honeycomb core and laminate finishes. LED lighting is fitted throughout. Core complement is the region of sixty-five crew members, leaving plenty of spare space for additional flight crew, trainees or other embarkees.

Other facilities include separate dining rooms for officers and ratings at upper deck level served by a common galley. Officers, senior ratings and junior ratings all benefit from their own lounges. A small medical facility includes a surgery and treatment room, as well as a three-bed hospital ward. In addition to serving the needs of the crew, this provides additional flexibility in secondary constabulary and humanitarian assistance roles. A Royal Navy surgeon lieutenant normally forms part of the complement.

Provision is made for two lifeboats and two rigid-hulled inflatable boats (RHIBs), which are launched from recesses located to port and starboard in the superstructure at upper deck level. There is also a position for a smaller dive boat at main deck level just forward of the superstructure. Each of the fully enclosed lifeboats – manufactured by Palfinger Marine Safety (formerly Harding) of Norway – provide seating for 130 personnel, more than the class's maximum complement.

HNOMS MAUD

To date, the only other realisation of the Aegir design family is the Royal Norwegian Navy's logistic support vessel *Maud*. A significant evolution of the Aegir 18/18R concept that also benefitted from work undertaken on the 'Tides', she was ordered under a 1.32bn kr (c. US$150m) contract awarded by the Norwegian Defence Logistics Organisation in June 2013. As for the 'Tides', construction was carried out by DSME, where first steel was cut on 22 May 2015.

Principal particulars for *Maud* are set out in Table 3.3.2. In contrast to the single-role focused 'Tides', *Maud* has been designed as a flexible, multi-role support vessel that can supply bulk and non-bulk consumables but can also undertake a wide range of other support functions. More specifically, she is intended to:

- Provide liquid and solid replenishment at sea in support of Norwegian and allied task groups. This

includes the ability to replenish at least two vessels with either liquid or solid stores simultaneously.
- Support medical and humanitarian operations through incorporation of an expandable role 1 hospital facility and the ability to transport significant quantities of containerised cargo.
- Act as a helicopter base and command platform.
- Undertake a range of secondary functions ranging from providing sealift and sea-basing support to the provision of repair and maintenance facilities.

Displacing some 27,500 tons and with an overall length of 183m, *Maud* is somewhat smaller than her British cousins. Whilst she is broadly similar in overall structure and layout, a significant proportion of her forward cargo spaces are given over to non-bulk, solid consumables. A greater proportion of her length is taken up by her superstructure, partly reflecting the provision of more extensive command and medical facilities.

Maud is able to transport 7,000 metric tonnes of F76 marine diesel and a further 300 metric tonnes of F44 aviation fuel, representing only around a third of the capacity for liquid stores found in a 'Tide'.[16] By contrast, she is able to accommodate as many as forty TEU and up to 200 tonnes of ammunition and/or other solid stores. It is also possible to ship alternative loads, such as military vehicles. Port and starboard RAS stations equipped with Rexroth rigs are located just forward of the bridge and RASCO whilst transfer by stern reel is also possible. A single 25-tonne crane is fitted further forward to the starboard of the ship's centreline. There are clear routes from the stores areas to the flight deck aft to facilitate VERTREP. The helicopter flight deck is large enough to operate helicopters up to the size of the US Navy's giant CH-53 Sea Stallion series. *Maud* will normally operate one NH-90 series helicopter, for which full maintenance support can be provided in the hangar. Alternatively, the hangar can provide stowage for one operational and one spare helicopter.

Table 3.3.2.

MAUD (A530) PRINCIPAL PARTICULARS

Building Information:	
Laid Down:	15 December 2015 Launched: 4 June 2016[1] Delivered: 16 November 2018[2]
Builders:	Daewoo Shipbuilding & Marine Engineering, Okpo, South Korea.
Dimensions:	
Displacement:	27,500 tons.
Overall Hull Dimensions:	183.0m x 25.9m x 8.6m.
Equipment:	
Armament:	Fitted for: 4 x Sea Protector weapons stations. Light machine guns.
Aircraft:	Flight deck and hangar for 2 x medium helicopters.
Countermeasures:	Likely to include ES-3701 electronic support measures (ESM) system & Terma decoy launchers.
Sensors:	1 x Terma Scanter 6200 surveillance/helicopter control radar. Navigation radar.
Communications:	Integrated communications system, including MF, HF, VHF and UHF and satellite links.
Cargo Capacity:	7,000 metric tonnes of F76 marine diesel and 300 tonnes of F44 aviation fuel. 200 tonnes of ammunition. 40 x TEU containers.
RAS & Handling Equipment:	2 x Bosch Rexroth RAS rigs (1 x starboard; 1 x port). Stern reel. 1 x 25-tonne Pellegrini Marine Equipment deck crane.
Propulsion Systems:	
Machinery:	CODLOD Hybrid Propulsion. 2 x 7.5MW Wärtsilä L46F series main diesels or 2 x GE hybrid machines powered by 2 x 3.2MW Wärtsilä generators driving twin shaftlines via two reduction gearboxes. 2 x Wärtsilä bow thrusters.
Speed:	Sustained speed of 18 knots. Endurance in excess of 10,000 nautical miles.
Other Details:	
Complement:	43 core crew. Accommodation for a total of 159 personnel.

Notes:

1. Date of final float-out.

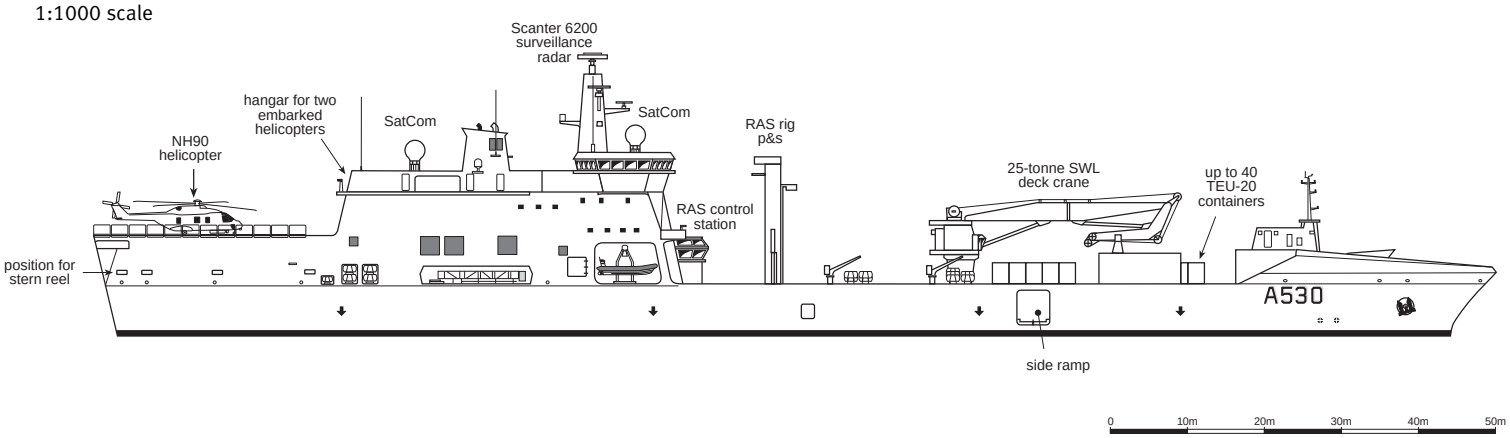
2. Ship was formally christened into Royal Norwegian Navy service on 21 May 2019.

A major feature of the design is the provision of a large, flexible medical facility. Developed in conjunction with Saab Medical, it extends over two levels. On 02 Deck – immediately forward of the helicopter hangar – is a triage room with easy access for casualties arriving via the helicopter flight deck. One deck below at 01 Deck level and accessible by lift is the main hospital encompassing operating, trauma, intensive care and CT facilities. The aft end of the facility is dual use, being allocated to lounges and spare accommodation for officers and non-crew members. However, beds and other equipment are stored behind screens to allow the spaces to be rapidly re-roled as high and low dependency wards in a medical emergency. Up to forty-eight patients can be accommodated. The facility's lift also extends further downwards to 1 Deck (Main Deck) level, where it can access a decompression chamber, as well as the ship's boats and a side ramp.

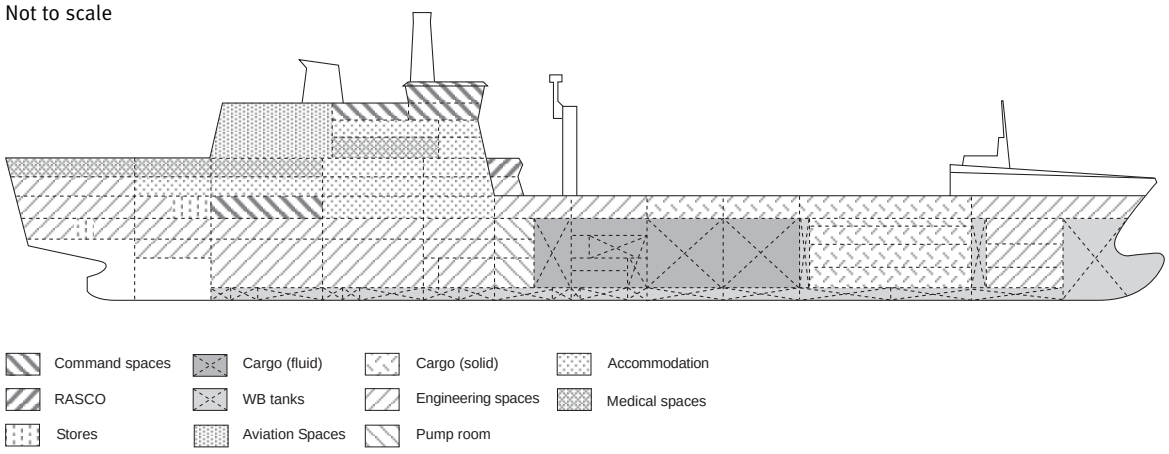
The side ramp also has an important function in one of *Maud*'s secondary roles, viz. easing access when she is acting as a mother ship for surface vessels and/or submarines berthed alongside. She is also equipped with mooring positions and water and power connections for these vessels, which can be resupplied with the assistance of the ship's crane. *Maud*'s surplus accommodation, catering and leisure facilities can be used by submariners and the crews of smaller craft to provide rest and relaxation in similar fashion to the destroyer and submarine depot ships of a previous era. There is additional cabin space for as many as 116 sailors in addition to the forty-three berths allocated for the ship's core crew.

Maud's propulsion system is based on the same hybrid CODLOD technology found in the 'Tides'. However, the Wärtsilä main diesels and, particularly, the diesel generators have a slightly higher power output. This reflects the requirement to operate in Arctic conditions – including the use of an anti-icing system – and the larger power demands of the ship's 'hotel' features. Command and control systems also reflect national preferences. For example, the main

Maud (2019)
1:1000 scale



General Arrangement
Not to scale



(Drawings © John Jordan, 2019)

A series of views of *Maud* taken in Oslo Fjord on 23 May 2019, two days after the ship's christening ceremony. The ship has a somewhat more 'stumpy' appearance than the longer 'Tides', an impression reinforced by the large crane used for handling solid cargo and the comparatively greater portion of her hull taken up by her superstructure and hangar. As well as being able to undertake replenishment at sea, she is designed to act as a helicopter platform and depot ship as well as undertaking command and control duties. A large and flexible medical facility means that she also has a significant capacity for humanitarian intervention. *(Theodor Obrestad Schei/Norwegian Armed Forces)*

surveillance and helicopter control radar is a Terma Scanter 6002, which provides data to a Wärtsilä Valmarine integrated bridge system.[17] She is due to be equipped with four Kongsberg Sea Protector weapons stations for self-defence.

Originally due to be delivered in September 2016, *Maud* experienced even greater delays during her construction process than the 'Tides'. In addition to the problems the RFA ships experienced, *Maud* also suffered damage to her propulsion system during initial trials in December 2017 that further postponed her delivery. She was finally delivered over two years late on 16 November 2018, arriving in Norway towards the end of March 2019. A formal christening ceremony was subsequently held in Bergen on 21 May 2019.

INTO SERVICE

The 'Tide' class fleet tankers have only seen a limited period of operational service to date but initial experience has been positive. BMT's Business Development Manager for Surface Ships, Ben Dunscombe, has reported exceptional feedback from operators on the superior performance of the hull form and propulsion systems compared with legacy vessels during RAS evolutions. There has been considerable interest in similar vessels from other navies as a result. Meanwhile, RFA officers have praised the high quality of build achieved by DSME in spite of some reports of minor teething problems after initial delivery.

The three 'Tides' that have now joined the operational fleet have already been busy supporting the Royal Navy fleet. Most notably, *Tidespring* formed part of the 'Westlant 18' deployment that saw the new carrier *Queen Elizabeth* carry out initial F-35B Lightning II trials. She was awarded the Fleet Effectiveness 'Ship of the Year' Trophy 2018 for Royal Fleet Auxiliaries. It seems that one 'Tide' will

Tidesurge and *Tideforce* pictured during replenishment at sea exercises in May 2019. They are well-designed and well-built ships that will provide the Royal Navy with a vital capability for many years to come. *(Crown Copyright 2019)*

always be assigned to supporting carrier operations, leaving the others available for other taskings or in refit. In February 2019 *Tidespring* began her first docking and maintenance period at Cammell Laird on Merseyside. The Birkenhead yard will be responsible for the maintenance of all four 'Tides' under the Future-In Service Support contracts awarded in October 2018.

Meanwhile the delays incurred during *Maud*'s construction mean that she has only just entered service with the Norwegian fleet. Previous reports have suggested that she will undergo training with the British Royal Navy's Flag Officer Sea Training (FOST) organisation before commencing operational tasking. In spite of inevitably limited experience to date, early reports of 'user experience' have also been good.

CONCLUSION

By the end of 2019, all four 'Tides' and *Maud* will have entered operational service. This makes it a good time to review the performance of these acquisition programmes. Whilst both were beset by delays during their construction and delivery phases, this is by far from being an exception in recent naval procurement the world over. More positively, both the RFA and the Royal Norwegian Navy appear pleased with the quality and performance of the resulting ships.

From BMT's perspective, this positive feedback should reinforce the credentials of the design approach adopted in the Aegir family. It seems that the twin-skeg hull form and hybrid CODLOD system incorporated in the new ships is proving a practical success in supporting the performance of complex RAS evolutions, increasing prospects of further customer adoption. Whilst they are very different ships with unique requirements, the FSS fleet solid support ships that form the next stage of the original MARS programme could well benefit from concepts and experience developed in the 'Tides'.

The combination of an evolved commercial design with the use of offshore build has also provided both the RFA and the Royal Norwegian Navy with significant economies. For example, it is understood that the overall 'Tide' programme – including UK customisation – ended up costing around £550m (c. US$700m), nearly £50m below the initially approved budget.[18] By way of comparison, France's recently announced contract for four domestically-produced FLOTLOG support vessels, based on Fincantieri's *Vulcano*, is reported to be valued at €1.7bn (US$1.9bn). The total budget for the two *Protecteur* joint support ships being built domestically to the German Type 702 *Berlin* class design under Canada's National Shipbuilding Strategy is an eye-watering CAD$3.4bn (US$2.6bn).

The arguments relating to the merits of domestic compared with offshore construction are currently being played out with respect to the RFA's proposed FSS solid support ships, which are due to be ordered in the course of 2020. As was the case for the 'Tides', their procurement has been opened to international competition. This has resulted in a UK consortium encompassing Babcock, BAE Systems, Cammell Laird and Rolls-Royce being shortlisted alongside DSME, Fincantieri, Navantia and Japan Marine United. The decision has attracted increasing criticism from a combination of politi-

Table 3.2.3: 'TIDE' CLASS LIST

NAME	YARD NO	STEEL CUT	KEEL LAID	FLOATED OUT[1]	NAMED	ACCEPTED	DEDICATED[2]
Tidespring (A136)	7044	24 June 2014	22 December 2014	25 April 2015	7 October 2015	12 January 2017	27 November 2017
Tiderace (A137)	7045	8 December 2014	8 June 2015	28 November 2015	1 December 2016	29 June 2017	2 August 2018
Tidesurge (A138)	7046	8 June 2015	7 December 2015	4 June 2016	29 August 2017	15 November 2017	20 February 2019
Tideforce (A139)	7047	2 December 2015	26 July 2016	21 January 2017	24 January 2018	May/June 2018	[Late 2019]

Notes:

1. Ships were floated out several times during the construction process. Date refers to final float-out before commencement of fitting-out process at DSME.

2. After acceptance, all ships returned to the UK via the Pacific for final fitting-out and customisation at A&P Group's Falmouth yard. Dedication – similar to commissioning – was scheduled after completion of post-customisation trials and represents the ships' entry into operational RFA service.

cians, trade unionists and commentators citing the benefits of 'onshore' built to the national economy.[19] The competing arguments are quite balanced. Although the delays to the 'Tides' have been used to support the domestic procurement agenda, the experience of their construction has been better than for many indigenous programmes. The Canadian experience also warns of the potential costs of protecting a domestic monopoly. Against this, the massive *Queen Elizabeth* construction programme has done much to revitalise the British shipbuilding sector and the JSS contract provides a major opportunity to build on this progress.

Whatever the future for JSS, the 'Tides' and *Maud* are well-designed and well-constructed ships that significantly enhance the capacity of their respective navies. They should prove invaluable assets in a more uncertain era.

Notes

1. See '2017 is the Year of the Navy' posted to the *Gov.UK* website on 1 January 2017 at: https://www.gov.uk/government/news/2017-is-the-year-of-the-navy

2. The Royal Fleet Auxiliary (RFA) is the uniformed civilian branch of the United Kingdom's Naval Service. Staffed by British merchant sailors, its job is to provide global logistical and operational support across tasks ranging from warfighting and counter-piracy to humanitarian assistance and disaster relief.

3. The term replenishment at sea (RAS) is used by the Royal Navy, NATO and many Commonwealth nations. The corresponding US Navy terminology is underway replenishment (UNREP).

4. For a more detailed overview of the development of replenishment at sea and current support ship designs see the author's 'Modern Naval Replenishment Vessels' in John Jordan (ed), *Warship 2018* (Oxford: Osprey Publishing, 2018), pp.136–51.

5. Much of the background information for this section is based on the UK National Audit Office's annual Major Projects Reports for the timescale in question available by searching: https://www.nao.org.uk/

6. The other elements of the MARS project were to be taken forward separately at a later date. As a result of the 2010 Strategic Defence & Security Review (SDSR 2010), the fleet solid support and joint sea-based logistic support ships were later merged into a single programme. This element of MARS was subsequently confirmed in SDSR 2015 and a competition to procure up to three of the resulting FSS fleet solid support ships is currently underway. These appear to be very much focused towards carrier strike group support, with the recently mooted littoral strike ship concept arguably taking up part of the role envisaged for the sea-based logistic support vessels.

7. Given the current political opposition to the potential award of the FSS contract to a foreign builder, it is interesting to note that the original decision to allow the MARS tankers to be subject to international bids was taken by a Labour administration. The subsequent decision to allocate 'Tide' class build to DSME was taken by the Conservative/Liberal Democrat coalition.

8. The full name for MARPOL 73/78 is the International Convention for the Prevention of Pollution from Ships 1973, as modified by the Protocol of 1978. It was developed by the International Maritime Organization to reduce maritime pollution. It contains a number of annexes, each relating to the regulation of various categories of pollutants. Over 150 countries representing around 99 percent of total global mercantile tonnage have signed the convention to date. Although the regulations do not apply to naval vessels, the ethical hazards involved in operating non-compliant ships and the risk of being refused entry into foreign ports has resulted in steadily growing pressure for their disposal.

9. Skegs are sternward extensions of the hull structure. In the Aegir designs they are used to enclose the shaft lines. The author understands the first large warships built to this configuration were the US Navy's two *North Carolin*a (BB-55) class battleships, which were commissioned in 1941. Early skeg designs were frequently associated with severe vibration but this issue appears to have been overcome. Recent studies suggest that current twin-skeg hull forms require around six percent less propulsive power at normal operating speeds compared with a single screw ship of the same cargo capacity.

10. A more detailed explanation of the potential benefits of the Aegir family was set out by Andy Kimber and Arne Magne Vik in the paper 'Future naval tankers – bridging the environmental gap – the cost effective solution' presented at the World Maritime Technology Conference 2006, London (Bath: BMT Defence Services Ltd, 2006). Then head of the Naval Architecture Future Platforms Team at BMT Defence Services, Andy Kimber was responsible for developing the Aegir concept. Arne Magne Vik was Managing Director of Skipskonsulent at the time.

11. Answer by Harriet Baldwin, Parliamentary Under-Secretary at the MOD on 8 November 2016 to Royal Fleet Auxiliary: Written question – 51473 posed by Douglas Chapman MP reported in Hansard at: https://www.parliament.uk/business/publications/written-questions-answers-statements/written-question/Commons/2016-11-01/51473/

12. DE&S Freedom of Information Act response to the author dated 16 February 2017.

13. Although all RAS stations are equipped with twin 7in hoses, most ships in Royal Navy service are only fitted to receive a single hose and would be serviced accordingly. Each hose has a theoretical transfer capacity of 650m3 per hour.

14. The design's stealth features were described in an article contained in the MARS Project Newsletter *Mars News – Issue No. 6* of November 2014 edited by DSME.

15. As of mid-2019 it seems DSM 30 mounts had been fitted only to *Tiderace* and *Tideforce*, with Phalanx yet to equip any ship.

16. This description has been informed by a presentation entitled *Logistic Support Vessel HMNoS Maud* given by DSME's Sung Jin Lee in 2014.

17. The author is grateful to Guy Toremans for supplying this information.

18. See Note 12 above.

19. See, for example, Richard Scott, 'Calls increase for UK to bring procurement of FSS onshore', *Jane*'s *Defence Weekly* – 12 June 2019 (Coulsdon: IHS Jane's, 2019). Recent reports suggest both DSME and Fincantieri have dropped out of the competition.

20. This article has benefitted greatly from the assistance of the following industry and Naval Service personnel involved with the 'Tide' class and *Maud* design and construction programmes. The author thanks them for their considerable help. All errors and omissions remain his own:

- Ben Dunscombe, Business Development Manager for Surface Ships at BMT Defence and Security.
- Simon Jones, Chief Naval Architect at BMT Defence and Security.
- Captain Shaun Jones, OBE RFA (retired). Captain Jones was involved with the MARS programme from its infancy and was Delivery Captain for all four 'Tides'.

Useful websites for further information on the RFA include Historical RFA at: http://historicalrfa.org/ and the RFA Association website at: http://www.rfa-association.org.uk/

3.3 SIGNIFICANT SHIPS

Author:
Norman Friedman

VIRGINIA (SSN-774) CLASS

Origins, Design Drivers and Description

With more than thirty units built, on order or planned, the *Virginia* (SSN-774) class will soon outnumber surviving *Los Angeles* (SSN-688) class attack submarines in the US Navy's inventory. If the *Los Angeles* was very much a Cold War submarine, the *Virginia* is a creature of the post-Cold War era. It is, however, well suited to the new Cold War which seems to be brewing in the Far East, the confrontation between the West and China.[1]

The *Virginia*s were born out of the fiscal crash at the end of the Cold War and also out of a new emphasis on littoral warfare, which meant deploying Special Forces and land-attack missiles. Later *Los Angeles* class submarines were given substantial Tomahawk batteries, which they employed successfully in the wars of the 1990s, in places like Iraq and Bosnia. They could also accommodate a dry deck shelter for Special Forces, but these were clearly appendages. Whilst still multi-mission boats, the ability to conduct operations in littoral waters was to be very much an integral part of the *Virginia* class design.

The *Los Angeles* class submarine *Columbia* (SSN-771) entering Pearl Harbor in June 2018. Although later members of the class were equipped with Tomahawk cruise missile batteries and enhanced facilities for Special Forces, they essentially remained a product of Cold War thinking. *(US Navy)*.

Left: *Virginia* (SSN-774) returns to the General Dynamics Electric Boat shipyard on 30 July 2004 following the successful completion of her first voyage in open seas; her 'alpha' sea trials. The accompanying press release reflected the changed environment the new submarine was designed for, stating '*Virginia* is the Navy's only major combatant ready to join the fleet that was designed with the post-Cold War security environment in mind and embodies the war fighting and operational capabilities required to dominate the littorals while maintaining undersea dominance in the open ocean'. *(General Dynamics Electric Boat via US Navy)*

Two images of the third and final *Seawolf* class submarine *Jimmy Carter* (SSN-23) pictured in Puget Sound in April 2017. Designed for lengthy operations in Soviet strategic missile submarine sanctuaries, the *Seawolf* class was too specialised, large and expensive for the post-Cold War era. SSN-23 herself was modified during construction to support Special Operations and actually commissioned after the lead member of the *Virginia* class. *(US Navy)*

BACKGROUND

The end of the Cold War forced the US Navy to reassess its priorities. This was not too different from the situation in 1945, when the navy had just won the greatest maritime war in history and now faced enmity with a land power, the Soviet Union. The question in 1945, and again in 1991, was how the massive US Navy could or should contribute to the United States' national security in a drastically changed world. Until 1991, the US Navy's agreed task had been to neutralise a variety of Soviet naval threats, including that posed by the huge Soviet submarine force. After 1991, the Soviet submarine force suffered a massive draw-down. Moreover, at least until around 2008, it seemed that Russia was hardly the primary security problem.

It seemed clear that Third World turmoil was a much more immediate problem, as reflected in the Iraqi invasion of Kuwait in 1990 and the subsequent American-led counter-attack. Within a few years, the US Navy was talking about the littorals as the most likely venue for future naval operations. Littoral areas were defined as the strip of land most directly affected by events offshore, and the adjacent strip of sea most directly affected by events ashore. The main example was generally the turbulent Gulf, although there were others, such as the Korean coastline. Littoral meant things like protracted reconnaissance and presence, the ability to deploy Special Forces, the ability to deal with mines and the ability to mount precision strikes. Problems included shallow warm water – which was very bad for sonar – and the presence of shore-based (and often concealed) anti-ship missiles. The latter might make submarines capable of mounting missile strikes far more valuable. Another factor was a conscious decision to limit the range of carrier attack aircraft on the theory that precision-targeted Tomahawks would suffice for deep strikes.

SEAWOLF (SSN-21) CLASS

In 1990 the US Navy was building a new *Seawolf* (SSN-21) submarine class, in effect the ultimate expression of Cold War submarine strategy. *Seawolf* was conceived to operate deep in Soviet strategic missile submarine sanctuaries on a protracted basis. For example, it was understood that a submarine would face the greatest danger passing in or out of the protected area. The longer she could stay in the sanctuary, the more she could do. To that end, *Seawolf* carried twice as many torpedoes as earlier US

Navy attack submarines. To survive, *Seawolf* was extremely quiet. She also had much larger, hence higher-gain, sonar arrays than previous submarines. All of that was quite expensive.

When she was conceived during the Cold War, *Seawolf* made excellent sense. The US Navy and its allies had spent decades facing massive Soviet submarine forces. They had not found any leverage with which to force back the mass of Soviet attack submarines. There had been speculation that the Soviet Union was increasingly dependent on its own strategic submarines, and that it had prioritised defending the bastions in which they operated, but no solid evidence. In the early 1980s, however, US naval intelligence learned positively that this speculation was correct. Putting pressure on the bastions would keep the bulk of the Soviet submarine force out of the North Atlantic, at least during the early phases of a war with the North Atlantic Treaty Organisation (NATO). *Seawolf* was an expression of that conclusion, which allowed the US Navy to emphasise offensive elements of naval strategy.[2] It was hugely expensive – and unaffordable in the post-Cold War drawdown.

It was certainly clear in 1991 that the US Navy still needed submarines. Their ability to operate invisibly was, if anything, more important given the unsettled character of the post-Cold War world. The question was how to build a satisfactory post-Cold War submarine affordably. That was quite difficult. In 1990 the United States was building submarines at a relatively high rate, which reduced overhead per submarine. Moreover, the navy was very reluctant to eliminate either of the two submarine yards, Electric Boat and Newport News. Yet keeping both in business at a very low construction rate would considerably increase unit cost. The only obvious point was that the next-generation submarine would have to be simpler and smaller than a *Seawolf*.

TECHNOLOGICAL DESIGN DRIVERS

Exploratory studies for a *Seawolf* follow-on began as early as 1988 but gained impetus as the Cold War came to an end. In January 1991, the Chief of Naval Operations (CNO) Admiral Frank Kelso

A detailed view of the fin (sail) of *Colorado* (SSN-788), a Block III *Virginia* class submarine, showing her distinctive photonic masts. The *Virginia* class boats have benefitted from the incorporation of a series of technological advances that have greatly improved their effectiveness. *(US Navy)*

A crew member at a photonic mast console onboard *Colorado* (SSN-788) uses a commercially-available game controller to manoeuvre her electro-optical 'periscope'. The combination of new technologies such as photonic masts with commercial 'off the shelf'' equipment are key aspects of the *Virginia* class design. *(US Navy)*

ordered the design of an affordable submarine, initially called 'Centurion', the submarine for the next century. A Mission Needs Statement was approved in October 1991 and was followed in January 1992 by a series of ranges of required performance. The cost goal seems to have been half as much as *Seawolf* or roughly the cost of a *Los Angeles* class boat. Further *Los Angeles* construction was rejected because that design had exhausted its growth margin and because it could not deal with the submarines the Soviets had been designing at the end of the Cold War. Whether or not the Russians remained friendly, their innovations might turn up elsewhere.

From the point of view of littoral operations, the most important new submarine requirement was that the boat's commander be able to disentangle an extremely complex environment, including very large numbers of ships and smaller craft. It must have seemed most unlikely that any large-submarine sonar, no matter how complex and how well processed, could handle this problem by itself. Sonar beams were just too wide. A true littoral submarine had to combine sonar data with optics. Although this requirement was never explicitly stated, the design which emerged suggests that it was well understood. In particular, the then new technology of electro-optics was used very effectively.

Electro-Optical Technology: To understand the importance of electro-optical technology, think back to how submariners generally used conventional periscopes in the past. A submarine commander would put up his periscope and spin it rapidly around the horizon. In so doing, he would form a picture of nearby activity in his head. Since putting up the periscope exposed the submarine to detec-

The helmsman's position in *Florida (*SSGN-728), one of four former *Ohio* class strategic missile submarines converted into cruise missile strike platforms. The use of electro-optical periscopes – which do not require a direct optical path between periscope head and eyepiece – provided much greater flexibility with respect to the layout of the *Virginia* class's command spaces. *(US Navy)*

tion, it was done rarely and the brief exposure had to be used very thoroughly. Much therefore depended on how well and how quickly the submarine commander could assimilate what he saw. For example, the quick periscope look was emphasised in the British Royal Navy's 'Perisher' course.

The quick look was associated with a quick attack. The submarine commander could see his target, and he could also see nearby escorts which might interfere. If not many ships were present, there might not be any need for a quick look. In this case they might be identified – and their courses plotted – entirely by passive sonar.

Now imagine a submarine in the Gulf, surrounded by dozens or hundreds of craft, some huge and some tiny, but possibly carrying anti-submarine weapons. Identification and tracking would be enormously difficult. Putting up a periscope and making sense of so complex a situation could be a lengthy, dangerous task. In many cases the submarine would not even be preparing an attack; for example, she might be preparing to remain in the area on a protracted basis for, say, electronic reconnaissance.

Beginning in the 1980s, a solution evolved. The periscope head could carry not a lens but instead a digital camera. Its product could be captured on multi-role displays in the submarine's control space. Operators could examine the images alongside sonar data, electronic intelligence and also alongside reference information, such as identification photos. Depending on how good the digital camera was, it could spend even less time above water than the most expert commander would spend using an optical periscope. At least as importantly, there was no longer a need for a direct optical path between periscope head and eyepiece, so the output end of the system no longer had to be directly under the periscope mast. The Royal Navy exploited this possibility in its *Vanguard* class strategic submarines in the 1990s.

The more complex the situation, the greater the need for operators and their consoles. The submarine's sensors – sonars, passive electronics, optics – all had to be used together. In previous US Navy submarines, the space for assembling and using the tactical picture was limited by the need to place it in the upper part of the pressure hull directly under the periscopes. In fact US Navy submarines typically had a sort of bridge in this space, a platform above the helmsmen on which the commander and executive officer could stand. There they could see a display of the tactical picture as it was understood.

A December 2018 view of *Delaware* (SSN-791), the latest *Virginia* class submarine to be launched, being rolled out of the construction hall at HII's Newport News Shipyard prior to float out. Large canvas covers obscure her flank sonar arrays. A realisation that further increases in array size would not be affordable meant that there was a focus on upgradable computer processing power to achieve the required sonar performance. *(Huntington Ingalls Industries)*

With an electro-optical periscope, there was no longer any need to place the command space on the relatively narrow upper deck under the submarine's fin (US Navy sail). Instead, it was moved down to the widest (middle) deck, as a much larger space filled with multi-purpose consoles used to assemble a usable tactical picture and then exploit it.

This shift was not a sacrifice in unit cost; it was a leap ahead in unit effectiveness in littoral waters. The *Virginia* class were to be the first US Navy submarines designed to utilise the new technology.

Processing Enhancements: Other steps were taken specifically to solve the cost problem. The *Seawolf* design incorporated massive sonar arrays which only a large-diameter hull could accommodate. It seemed most unlikely that they – or a further even higher-gain sonar development – would be affordable.[3] The acoustics community realised, however, that the big *Seawolf* arrays represented a particular choice in sonar development and that there was an alternative. Sonar performance is essentially due to a combination of gain (array size) and processing power. It seemed clear that processing offered a huge potential, particularly since computer performance was advancing so rapidly. That could potentially be applied not only to a new submarine but also to existing ones.

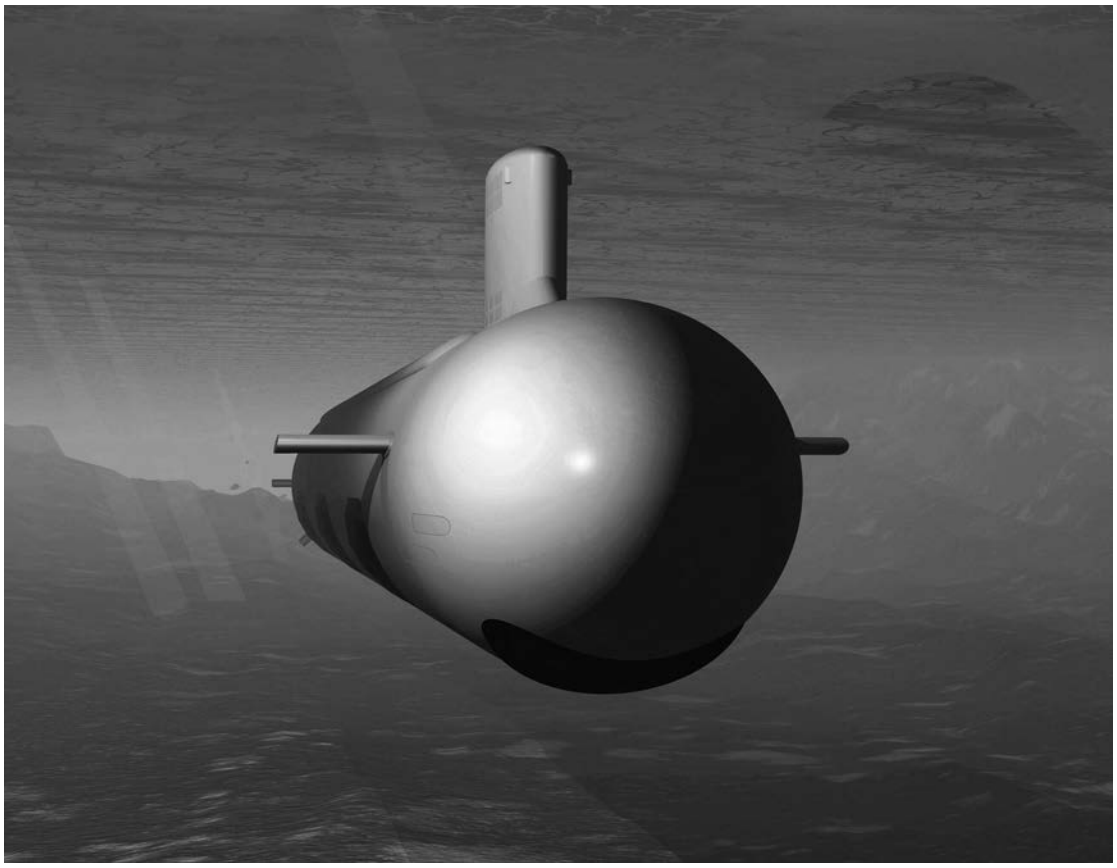
The new programme was called Acoustic Rapid COTS Insertion (A-RCI), COTS meaning unmodified commercial 'off the shelf' equipment. It was later designated AN/BQQ-10. A-RCI defined a series of new processors. These were to reflect the current state of commercial practice to ensure reliability rather than attempting to achieve the most advanced possible state of the art. Submarines were fitted so that processors or banks of processors could be changed relatively easily. Software was also refreshed more rapidly than in the past. This practice was soon extended to naval aircraft and to the

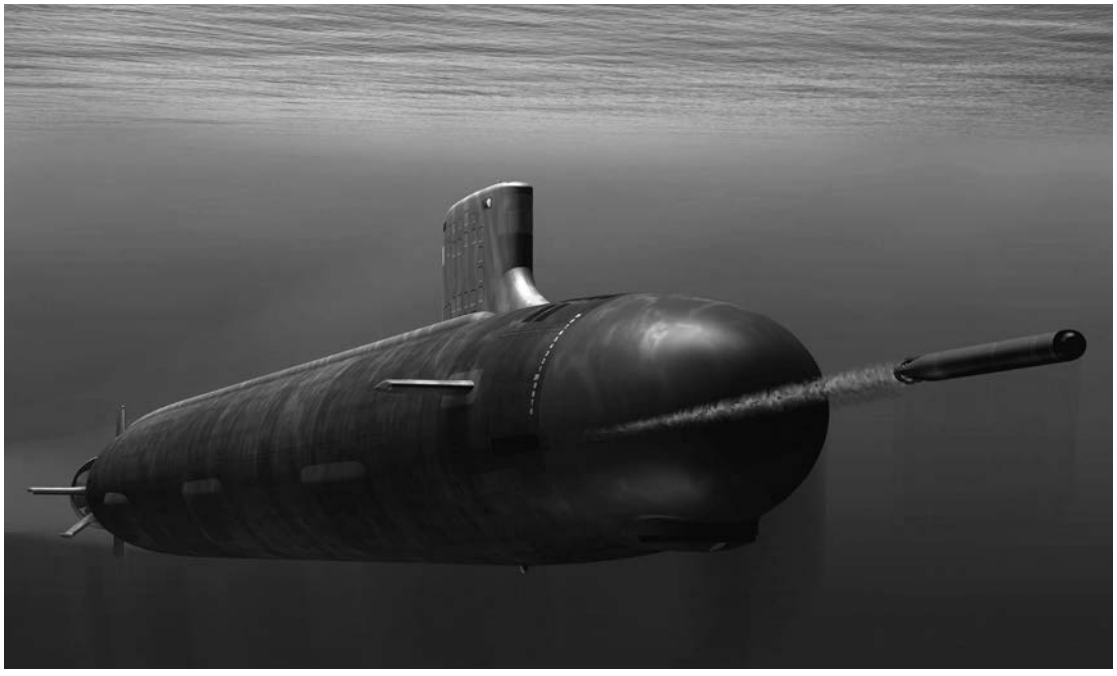
A series of photographs taken during a Tomahawk flight testing exercise conducted by the *Los Angeles* class submarine *Annapolis* (SSN-760) off the California coast in June 2018. The introduction of upgradable COTS technology into submarine combat systems necessitated a split into separate tactical control (TCS) and weapon control (WCS) elements so that only the latter required rigorous – and lengthy – certification to prevent the risk of accidental weapon release. *(US Navy)*

surface fleet. Upgrades are essentially invisible, but they have been enormously significant. As well as being fitted to the new *Virginia* class, A-RCI was also applied to the existing *Los Angeles* and *Ohio* (SSBN-726) class boats.

The idea of opening submarines to periodic hardware (processor) and software upgrades extended to the combat system, CCS Mk 2 (AN/BYG-1). However, there was one problem. In the past, the single integrated combat system created an accepted tactical picture and then – if necessary – directed weapons against targets the system tracked. It was therefore essential that the system be certified so that it could not inadvertently fire or direct a weapon. This was necessarily a lengthy process and could not possibly keep up with rapid upgrades. The US Navy's solution, announced in 2002, was to split the system into separate tactical control (TCS) and weapon control (WCS) elements. TCS, which created the tactical picture, could be refreshed to exploit new digital technology. WCS, which controlled torpedo and Tomahawk missile firing, did not need constant improvement. Whilst it used data TCS produced, it was the only part of the combat system which had to be certified.

Power and Propulsion: The new emphasis on digital operation also meant a shift towards electric power for vital sub-systems such as the submarine's planes and rudders. Thus the new submarine was designed





Two graphics of the *Virginia* class design dating from 2002 and 2003. Work on the new submarine – first known as 'Centurion' and then the NSSN – began in earnest in 1992 and was focused on meeting seven core missions set out in a Missions Needs Statement. A lead design contract was subsequently awarded to General Dynamics Electric Boat in 1996. *(General Dynamics/ US Department of Defense)*

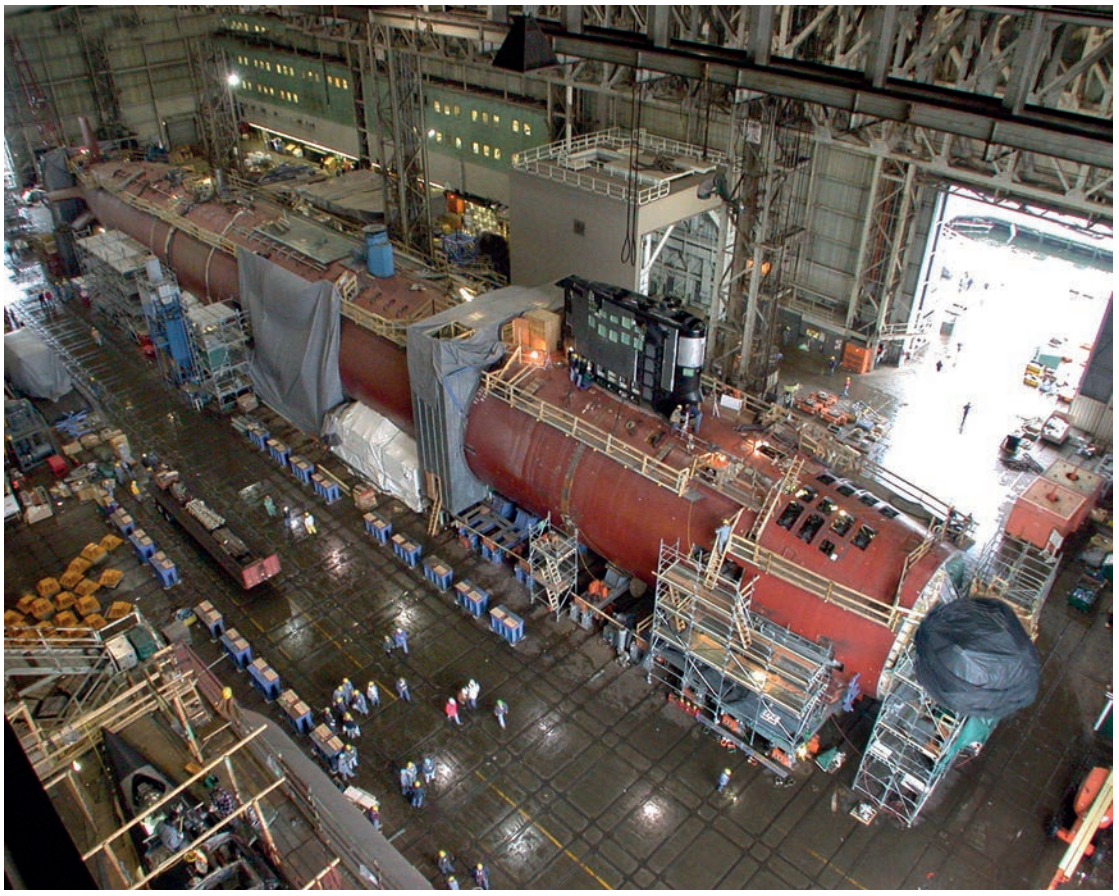
to use what amounts to 'swim by wire' control, i.e. the use of fibre-optics to control electric motors digitally rather than by the electro-hydraulics of the past. Benefits doubtless included saving considerable weight, which in a submarine is always in short supply. It also probably solved some control problems. To the extent that the controls are linked to the combat system, such linkage should also improve reaction to enemy attacks.

Reactor design was another important means of reducing life-cycle cost. Past attack submarines had to be refuelled periodically; these big refuelling stops were also opportunities for other upgrades and, hence, were expensive.[4] *Seawolf* introduced a one-shot reactor that never needed to be refuelled during the submarine's operational life, a cost reducer which helped justify her high unit production cost. The new submarine was also designed to avoid refuelling, incorporating a somewhat less powerful one-shot reactor designated S9G.[5] Like *Seawolf*, the new submarine was also designed to use a pump-jet propulsor instead of a conventional propeller, drastically reducing noise.

DESIGN DEVELOPMENT THROUGH TO CONSTRUCTION

Work on the new submarine began in earnest in 1992. It had to be as quiet as *Seawolf*. Whilst it could be slower, it had still to be fast enough to work with surface forces, which suggested at least *Los Angeles* class speed. The combat system could be simplified but it had to be based around open architecture technology. Crew size had to be minimised.

The Mission Needs Statement listed seven core missions, viz. (i) covert strike (Tomahawk attack), (ii) anti-submarine warfare, (iii) anti-ship warfare, (iv) battle group support, (v) covert intelligence gathering, (vi) covert minelaying, and (vii) special operations. Stealth was essential to all of these operations. New technologies which might be incorporated in the submarine were classified by their maturity (risk level). The low-risk group included the electro-optic (photonic) mast and combat system components. An important factor was reluctance to



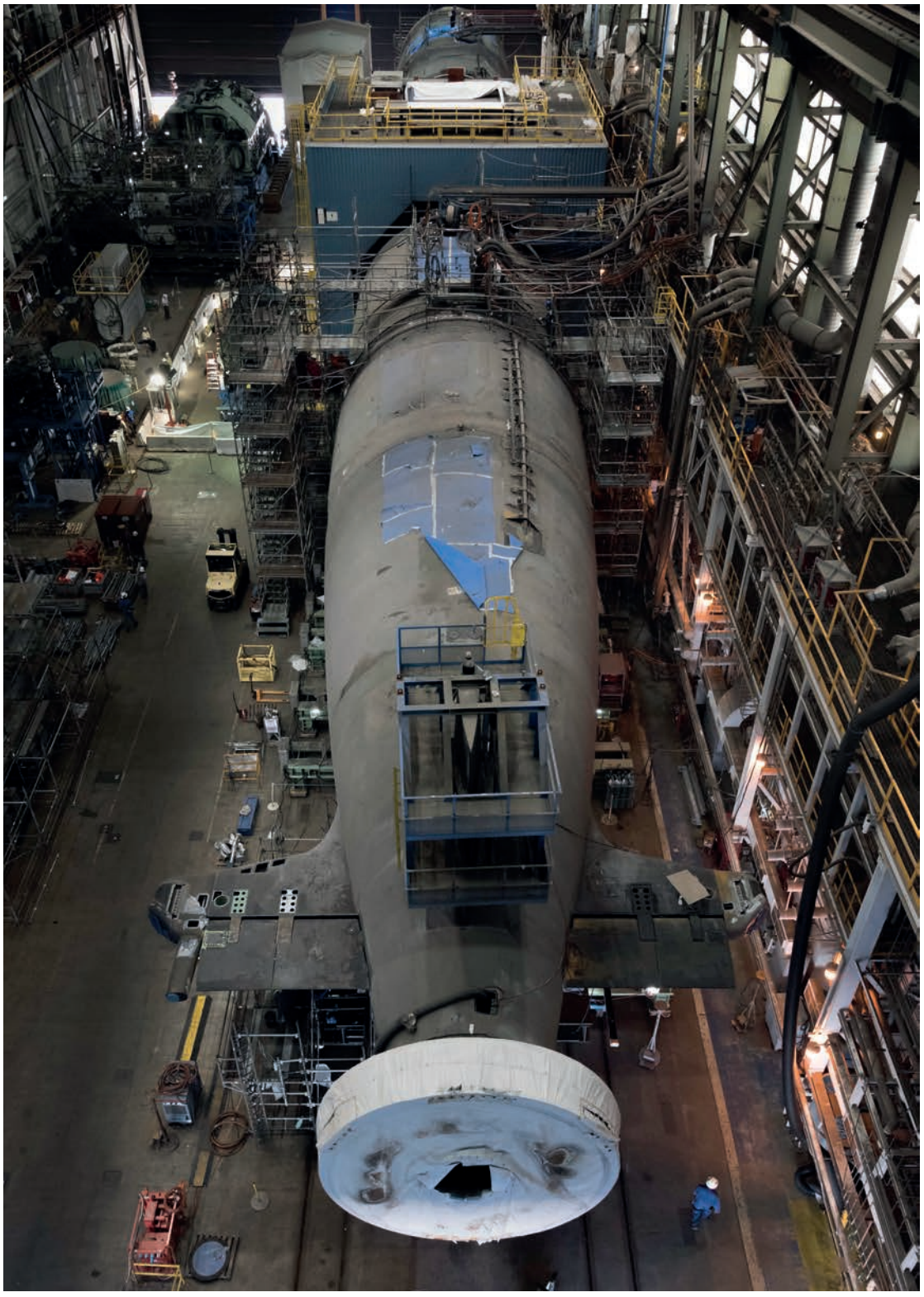
Construction of the *Virginia* class has been based on a partnership between General Dynamics Electric Boat and Newport News Shipbuilding (now part of Huntington Ingalls Industries), with each building specific modules for the submarines whilst alternating the construction of their reactor compartments and final assembly. This picture shows the lead boat, *Virginia* (SSN-774) under assembly at Electric Boat in Groton Connecticut in April 2003. *(US Navy)*

introduce more than one major technology in a submarine class. The issue seems to have been the multiple technology leaps incorporated in *Seawolf*. For the new submarine, everything had to go to sea before being adopted: a new lightweight side array, a non-penetrating mast, a reverse-osmosis distilling plant, a pump-jet propulsor, and a distributed combat system. Most were tested on board *Los Angeles* class submarines.

Studies were commissioned from a private yard, probably Electric Boat, to define a lower boundary for the new submarine: a 5,000 ton submarine as quiet as *Seawolf*.[6] The resulting design was too slow and it could not accommodate the desired vertical missile launcher, giving it a lower-than-required missile launch rate. It also failed other current standards. A design to current US Navy standards would displace 5,800 tons but would also be too slow and without vertical missile tubes. The studies showed that 6,000 tons was an effective lower limit. Any submarine displacing more than 8,500 tons, however, would be so close to *Seawolf* as not to be worthwhile. A submarine somewhere in the middle of this size range could accommodate vertical launch tubes (at the upper end, 6–8 torpedo tubes and 16 or more vertical tubes). On 28 August 1992 'Centurion' was formally approved as an acquisition programme. The first unit was tentatively included in the FY1998 programme for completion in 2003. The US Navy asked for initial R&D money, e.g. for the required smaller reactor, in FY1994.

Approval led to a series of trade-off studies, candidates including an updated *Los Angeles*.[7] The new design was designated the New Attack Submarine (NSSN). There was subsequent discussion as to whether further *Seawolf* construction was preferable and also interest in a series of specialised versions, such as a Special Forces version. Ultimately, the plan

Virginia (SSN-774) seen being moved out of her assembly hall prior to float out and christening in August 2003. Constructed using modular techniques, over 80 percent of the submarine's outfitting was complete by the time her pressure hull had been welded up. *(US Navy)*



Newport News Shipbuilding in Virginia is the other yard involved in *Virginia* submarine class construction. This picture shows *Delaware* (SSN-791) – the latest member of the class to be floated out – in the final stages of assembly in September 2018. *(Huntington Ingalls Industries)*

for a single, standard newly-designed submarine survived these and other challenges.

There was also debate about construction strategy. The US Navy – mindful of previous problems – wanted the new submarine designed and the prototype built by a single yard, awarding Electric Boat the lead design contract for NSSN in 1996. However, Congress feared that concentrating submarine design in one yard might make it impossible for that expertise to survive in the other. Accordingly, the FY1996 National Defense Authorization Act directed that contracts for the first four submarines should alternate between Electric Boat and Newport News. Subsequently the two yards proposed – and received approval – to build the new submarines as a team. Under the arrangement, Electric Boat would be the single design agent and prime building contractor, but Newport News would get about half the work. The submarine would be built in modules, which were largely outfitted before being joined together. More specifically. Electric Boat would be responsible for the pressure hull, engine room and the command and control spaces whilst Newport News would be responsible for the stern, habitability and machinery spaces, weapons handling room, fin and bow. Each would alternate work on the reactor compartment and on the final assembly, test, outfit and delivery of successive submarines.[8]

The modular technique had been introduced in the *Ohio* class strategic submarines but it was used far more intensively with NSSN. The extent of pre-outfitting can be measured by the percentage of the submarine complete before the pressure hull is welded up: 48 percent in *Ohio*, 81 percent in *Virginia*. Pre-outfitting makes it possible to test modules, such as the command and control element, before they are installed on board.

The first four NSSNs were ordered on 30 September 1998 under a block contract designed to contain costs and covered procurement for FY1998, FY1999, FY2001 and FY2002. On 10 September 1998 then Secretary of the Navy, John Dalton, had announced that the lead boat of the new class would be named *Virginia*.

VIRGINIA CLASS DESIGN

The *Virginia* class has been ordered under various blocks incorporating improvements in design or construction methodology. The first four became Block 1. The next six were Block II (one in FY2003, five in FY2004–08), followed by eight Block III (FY2009–13) and ten Block IV (FY2014–18). All but one of these were built under multi-year procurement contracts. A further multi-year procurement programme will cover the submarines purchased between FY2019 and FY2023, which will become the Block V members of the class. Current plans envisage *Virginia* class procurement stretching beyond this period.

Design particulars for *Virginia* and the Block I members of the class are set out in Table 3.3.1. Block II *Virginia*s incorporated improved construction methodologies with fewer sections but were virtually identical. The emphasis on littoral operations was evidenced by the provision of a dedicated nine-man swimmer space and lock-out hatch (a modified escape hatch) and also in the provision of a short-range obstacle and mine detection sonar, under the submarine's chin. This sonar is probably

Table 3.3.1.

VIRGINIA (SSN-774) PRINCIPAL PARTICULARS

Building Information:	
Keel Laid Down:	2 September 1999 Launched: 3 August 2003[1] Commissioned: 23 October 2004
Builders:	General Dynamics Electric Boat, Groton, CT from modules fabricated by Electric Boat & by Newport News Shipbuilding VA[2]
Dimensions:	
Displacement:	c.7,800 tons dived displacement.
Overall Hull Dimensions:	114.9m x 10.4m x 9.8m.
Weapons Systems:	
Armament:	4 x bow 21in (533mm) torpedo tubes. Space for up to c. 26 torpedoes or equivalent (of which 4 in the tubes). 12 x Mk 45 VLS tubes. Typical weapons outfit includes Mk 48 ADCAP torpedoes, Tomahawk cruise missiles & Mk 60 & Mk 67 mines. Integral 9-man lock out chamber.
Countermeasures:	External and internal anti-torpedo decoys. AN/BLQ-10 electronic support measures (ESM) system.
Principal Sensors:	AN/BQQ-10 A-RCI sonar system. Spherical bow-mounted active/passive array; lightweight wide aperture flank passive arrays; high frequency active fin & chin arrays. AN/TB16 & AN/T29A towed arrays. AN/BVS-1 photonic masts. AN/BPS-16 navigation radar.
Combat System:	AN/BYG-1 (CCS Mk II) combining tactical control system (TCS) & weapon control system (WCS) elements. Integrated communications.
Propulsion Systems:	
Machinery:	Nuclear-powered steam turbine. 1 x S9G pressurised water reactor & 2 x steam turbines. Combination provides c. 40,000shp (30MW) through one shaft with pump jet propulsion. Auxiliary propulsion motor.
Speed and Range:	Designed maximum speed is significantly in excess of 25 knots. Endurance is effectively only limited by provisions carried.
Diving Depth:	Classified. Likely c. 500m.
Other Details:	
Complement:	c. 15 officers & 120 enlisted.
Class:	Four *Virginia* Class Block I boats – *Virginia* (SSN-774), *Texas* (SSN-775), *Hawaii* (SSN-776) and *North Carolina* (SSN-777) commissioned between 2004 and 2008. Thirteen other members of the class in Block II and Block III configurations delivered to date.

Notes:

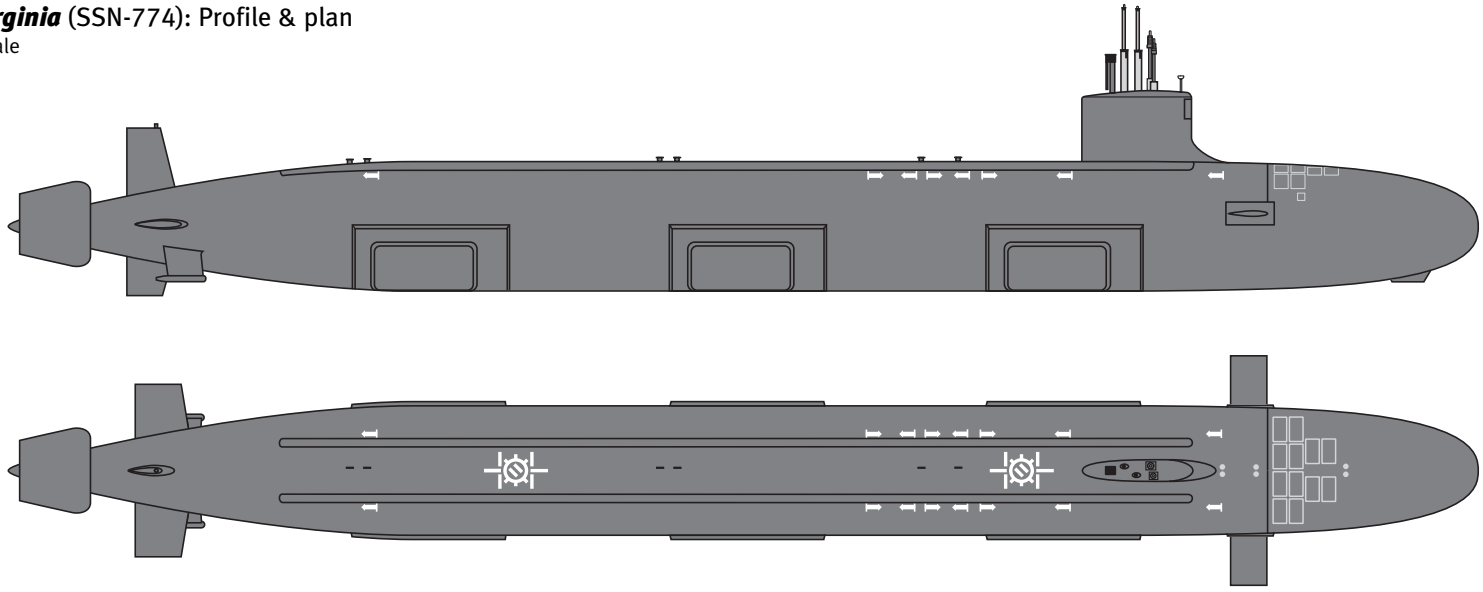
1. Date floated up. A formal christening ceremony was held on 16 August 2003.

2. Newport News Shipbuilding now forms part of Huntington Ingalls Industries.

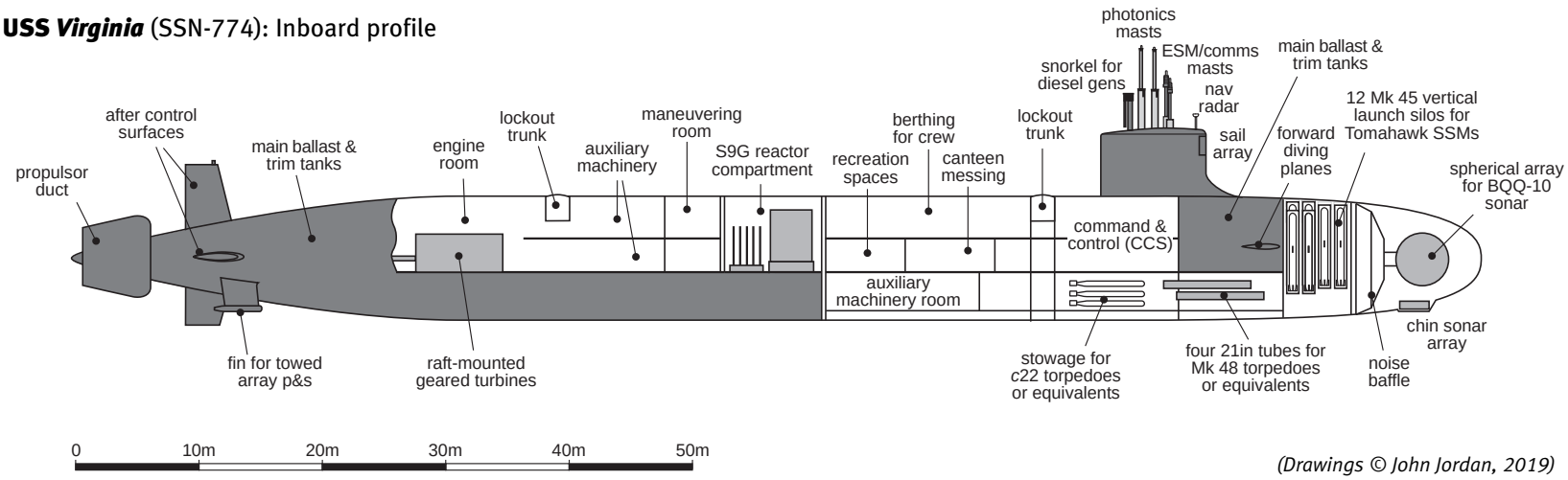
also intended for covert oceanography, which would be important in relatively shallow littoral waters into which a battle group might come. While the *Virginia* class was being designed, the US Navy was beginning to develop unmanned underwater vehicles (UUVs), beginning with a mine-reconnaissance device a submarine might deploy. Although this vehicle was never adopted, through the development of the *Virginia* class the Navy saw UUVs as a vital future adjunct to manned submarines. The boat's torpedo room is designed so that weapon stowage and handling can quickly be replaced by UUVs and swimmer delivery vehicles. There is also provision for a single dry deck shelter abaft the fin.

Because money was so tight after the Cold War, there was enormous emphasis on cost control throughout early *Virginia* class production. The early Block I and Block II *Virginia*s proved to be more expensive than desired in spite of some of the performance compromises inherent in the design, leading to efforts to find additional savings to ensure orders for two submarines each year would be affordable. In 2005 then CNO Admiral Michael Mullen pressed for unit cost to come down to about US$2

USS *Virginia* (SSN-774): Profile & plan
1:600 scale



USS *Virginia* (SSN-774): Inboard profile

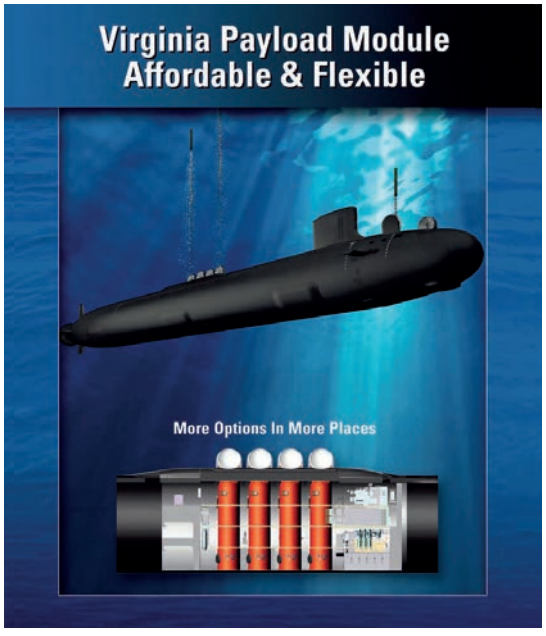


(Drawings © John Jordan, 2019)

Virginia pictured leaving Portsmouth Harbour UK in August 2013. She is the lead member of the class and the first of four Block I boats. Subsequent, Block II members of the class were notable for using improved construction techniques whilst the next, Block III batch – which were ordered under a multi-year procurement contract – were substantially redesigned for both cost and operational effectiveness. *(Conrad Waters)*

VIRGINIA Class Bow, Redesign For Affordability
Reduced Cost, Increased Flexibility
Multiple All-Up-Round Canister
Large Ocean Interface Leverages SSGN Technology Developments
Large Aperture Bow Array

Block III and later *Virginia* class submarines were designed with a revised bow for reasons of both economy and effectiveness. The key changes were the use of a new large aperture bow array and new missile canisters housing multiple Tomahawk cruise missiles, the latter often referred to as Virginia Payload Tubes. Overall savings on later Block III submarines were in the order of US$400m compared with previous blocks, around half of which came from changes to construction practices and design. *(US Navy)*



A number of the planned Block V *Virginia* class submarines will be equipped with a Virginia Payload Module (VPM) – a hull plug incorporating four, seven round canisters for Tomahawk cruise missiles. The additional twenty-eight weapons will substantially boost overall firepower. *(US Navy)*

billion, an unprecedented c.US$400m (c. 20 percent) reduction in a mature ship design. Around half of this was to be achieved by higher production rates and multi-year procurement; the balance was to come from major redesign and more effective construction.

The most notable revision to the resulting Block III submarines was a drastic change in the bow sonar. The spherical array was replaced by a Large Aperture Bow (LAB) array spread over the bow, which offered better passive capability but slightly reduced active capability. Since passive capability was far more important, this was a perfectly acceptable solution. LAB in turn freed bow space. The bow ballast tanks could be rearranged to accommodate two large-diameter Virginia Payload Tubes (VPTs) on the centreline instead of the twelve small-diameter vertical tubes of the original Block I and Block II submarines. The initial VPTs were redesigned Multiple All-Up Round Canisters (MACs) adapted from those used in the four *Ohio* class boats that were converted into cruise missile submarines (SSGNs). Each contains six Tomahawks, but alternative loadouts are possible.

Enhancements to the class have continued with further procurement contracts. Block IV (SSN-792 and beyond) is a Block III modified for easier maintenance, reducing major overhauls over the life of a submarine from four to three. In effect that adds

Table 3.3.2: *VIRGINIA* (SSN-774) CLASS ATTACK SUBMARINES: CLASS LIST

Number	Name	Integrator	Programme Year	Ordered	Commissioned
BLOCK 1 (4 BOATS)					
SSN-774	*Virginia*	GD Electric Boat	FY1998	30 September 1998 (Block Buy)	23 October 2004
SSN-775	*Texas*	Newport News SB	FY 1999	30 September 1998 (Block Buy)	9 September 2006
SSN-776	*Hawaii*	GD Electric Boat	FY 2001	30 September 1998 (Block Buy)	5 May 2007
SSN-777	*North Carolina*	Newport News SB	FY 2002	30 September 1998 (Block Buy)	3 May 2008
BLOCK II (6 BOATS)					
SSN-778	*New Hampshire*	GD Electric Boat	FY2003	14 August 2003[1]	25 October 2008
SSN-779	*New Mexico*	Newport News SB	FY2004	14 August 2003 (MYP)[1]	27 March 2010
SSN-780	*Missouri*	GD Electric Boat	FY2005	14 August 2003 (MYP)[1]	31 July 2010
SSN-781	*California*	Newport News SB	FY2006	14 August 2003 (MYP)[1]	29 October 2011
SSN-782	*Mississippi*	GD Electric Boat	FY2007	14 August 2003 (MYP)[1]	2 June 2012
SSN-783	*Minnesota*	Newport News SB	FY2008	14 August 2003 (MYP)[1]	7 September 2013
BLOCK III (7 BOATS + 1 BOAT UNDER CONSTRUCTION)					
SSN-784	*North Dakota*	GD Electric Boat	FY 2009	22 December 2008 (MYP)	25 October 2014
SSN-785	*John Warner*	Newport News SB	FY2010	22 December 2008 (MYP)	1 August 2015
SSN-786	*Illinois*	GD Electric Boat	FY2011	22 December 2008 (MYP)	29 October 2016
SSN-787	*Washington*	Newport News SB	FY2011	22 December 2008 (MYP)	7 October 2017
SSN-788	*Colorado*	GD Electric Boat	FY2012	22 December 2008 (MYP)	17 March 2018
SSN-789	*Indiana*	Newport News SB	FY2012	22 December 2008 (MYP)	29 September 2018
SSN-790	*South Dakota*	GD Electric Boat	FY2013	22 December 2008 (MYP)	2 February 2019
SSN-791	*Delaware*	Newport News SB	FY2013	22 December 2008 (MYP)	[Under construction]

Notes:

1. Six submarines were originally contracted under a block buy arrangement on 14 August 2003 which was then envisaged to cover four submarines (one p.a.) for FY2003 to FY2006, with two additional submarines planned for FY2007. On 29 January 2004 a revised multi-year procurement (MYP) contract was signed which covered one submarine each year for FY2004 to FY2008. The contract also covered the sixth submarine authorised in FY2003 but, as it was already under construction, it did not form part of the multi-year procurement agreement. The MYP was more favourable to the builders than the block buy approach as it allowed bulk purchases of materials for all the planned submarines.

2. Ten additional Block IV submarines were ordered under a further MYP contract on 28 April 2014. These are *Vermont* (SSN-792) and *Oregon* (SSN-793) under FY2014 procurement; *Montana* (SSN-794) and *Hyman G. Rickover* (SSN-795) under FY2015; *New Jersey* (SSN-796) and *Wisconsin* (SSN-797) under FY2016; *Massachusetts* (SSN-798) and *Idaho* (SSN-799) under FY2017; and *Arkansas* (SSN-800) and *Utah* (SSN-781) under FY2018. Two further submarines – intended to be the first of a ten-boat Block V order – were authorised under FY2019 procurement.

This Page & Right: The Block III *Virginia* class submarine *Indiana* (SSN-789) pictured on sea trials in the North Atlantic on 22 May 2018. Assembled at Newport News, she was commissioned on 29 September 2018 as the sixteenth member of the class. Block III boats feature a number of significant enhancements over earlier *Virginia*s, notably a revised bow sonar and the use of large diameter Virginia Payload Tubes (VPTs) in place of the small diameter single-missile tubes used previously. A further upgrade will follow with the planned Block V members of the class, many of which will incorporate a Virginia Payload Module (VPM) to increase missile-carrying capacity. *(US Navy)*

active submarines, allowing each boat to make one additional deployment over its lifetime.

Block V is envisaged as a ten or eleven-boat series beginning with SSN-802 and SSN-803 authorised in FY2019. Long-lead items for these two submarines were ordered in 2017 but full construction contracts – which will be placed as part of a multi-year procurement for ten boats and one optional unit – had not been awarded as of June 2019. It is intended that this batch will, in part, be used to restore the mass cruise missile capacity which will be lost when the four converted *Ohio* class cruise missile submarines (SSGNs) are retired during the coming decade. To this end, some of the Block V submarines will be lengthened with the insertion of a c. 84ft Virginia Payload Module (VPM) equipped with four large-diameter launch tubes, each of which can accommodate seven Tomahawk cruise missiles. Counting the two bow modules that will provide up to forty Tomahawks per submarine; still a fairly modest total compared to 162 found in an SSGN.[9]

Although *Virginia* class procurement is slated to continue, it is not entirely clear what comes next. Published plans suggest a succession of at least two more Blocks (ten each of Block VI and Block VII) followed by an entirely new design, tentatively designated SSNX.[10] It now seems likely that the littoral attack mission will decline compared to more conventional submarine missions required as the United States confronts China. In that case, the need for the additional cruise missile capacity associated with Block V may shrink and something similar to Block IV may be built in greater numbers.

Notes

1. All views expressed are the author's and should not necessarily be associated with the US Navy or with any other entity with which he has worked.

2. This strategy was, however, decidedly not accepted throughout NATO, with many members continuing to emphasise defensive anti-submarine operations. This had significance consequences when the Cold War ended. After the Soviet Union collapsed, the US Navy was left with an offensively-oriented fleet which was well adapted to project power into the unstable Third World. It discarded most of its ASW-oriented frigates, but retained its carriers and their escorts. Moreover, its recently developed Aegis system was extremely well adapted to dealing with the main anti-ship missile threat in the Third World, viz. sudden pop-ups by shore-based weapons. Earlier missile systems were not, and ships armed with them were also discarded. Meanwhile, the NATO navies that had emphasised anti-submarine warfare escorts found themselves disposing of many of their ships after the Cold War ended. This was, perhaps, unfortunate given the need for a naval presence in unstable places such as the Persian Gulf.

3. The main recent upgrades to sonar have been lightweight side arrays and new towed arrays.

4. As built, *Los Angeles* was credited with a 10–13-year reactor life. This meant that it required two refuelling stops during a c. 32-year career. Later units had upgraded cores credited with a 16–20-year lifespan. During the run down after the Cold War, some *Los Angeles* class submarines were laid up instead of being refuelled.

5. The S9G reactor designation refers to the characteristics that (i) the reactor is for a submarine (S) platform, (ii) it is the ninth (*9*) generation of reactor designed by the contractor, and (iii) the contracted designer is General Electric (G). The previous General Electric S8G reactor was used in the *Ohio* class strategic missile submarines, the *Seawolf* class using the Westinghouse-manufactured S6W reactor.

6. *Seawolf*'s silencing was attributed to double sound-mounting and to the adoption of a pump-jet propulsor. A small hull could accommodate only single sound-mounting. Without the pump-jet, the submarine could be detected at twice *Seawolf's* detection range.

7. This cost and operational effectiveness analysis (COEA) was standard Department of Defense practice. It examined six alternatives, including a forward-based non-nuclear submarine, possibly with air-independent propulsion. The COEA was completed on 2 August 1993. It left three alternatives alive: an upgraded *Los Angeles*, a downgraded *Seawolf* and a new design. The COEA concluded that a new design would be worthwhile only if series production amounted to more than ten units.

8. The US Navy appears to have been willing to divert submarine construction away from Newport News because it had nuclear powered aircraft carrier (CVN) construction to sustain its specialised skill base. Congress disagreed. The resulting partnership arrangement is unique and has allowed the United States to secure two submarine building yards, a valuable capacity now that submarine construction is again ramping up.

9. Current reports suggest the VPM will equip the second *Virginia* class submarine procured in FY2019, two of the three submarines requested in the FY2020 budget and one of two submarines planned for FY2021. Both boats planned for FY2022 and FY2023 will also receive the module.

10. This acquisition profile is contained in the *Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for Fiscal Year 2020* (Washington DC: Office of the Chief of Naval Operations, 2019), p.14.

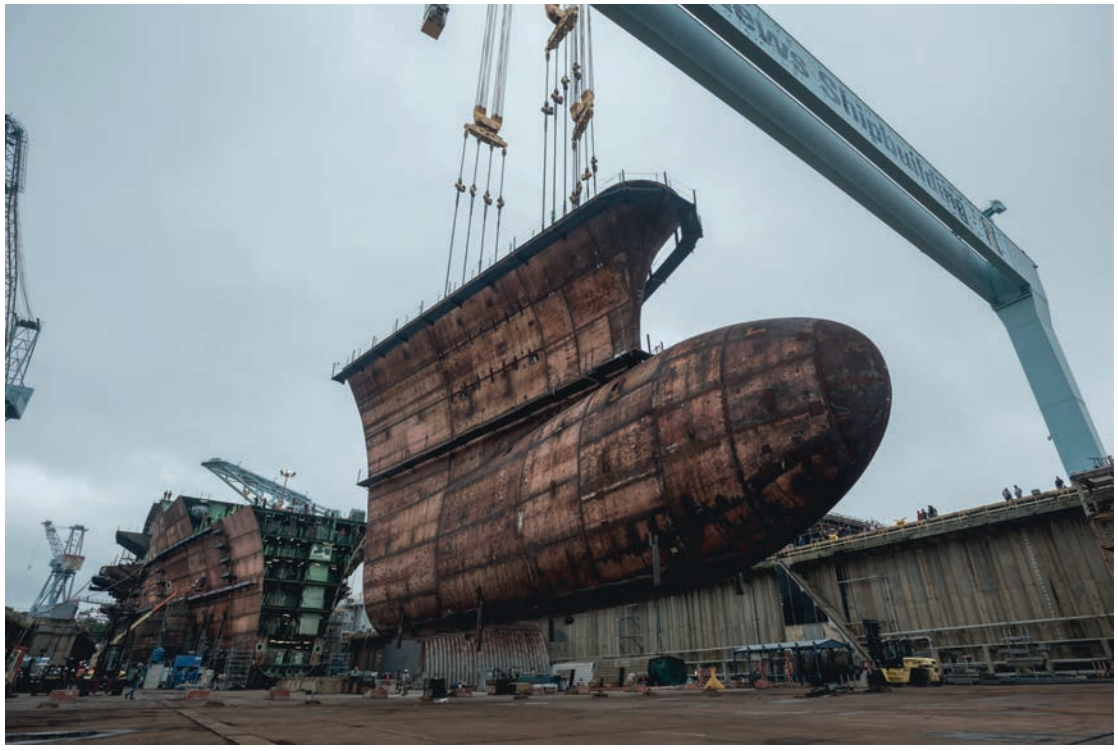
4.1 TECHNOLOGICAL REVIEW

WORLD NAVAL AVIATION

A Review of Recent Developments

Author:
David Hobbs

Alarmed by the development of anti-access and area denial (A2/AD) weapons which out-range its carrier-based air wings, the Pentagon's FY2020 budget proposals have focused on establishing dominant military capabilities in every potential sphere of operation within a decade. Extra money is to be made available but some programmes have been cut to fund 'leap-ahead', complex technologies that are intended to enter operational service within the next decade. This overview concentrates on these new technologies and their impact on large, light and specialised aircraft carriers and their aircraft. The article also looks at progress with the F-35 programme after a year in which the US Navy's F-35C became the third and final 'Lightning II' variant to achieve initial operational capability.



Good progress is being made constructing the second *Ford* class carrier, *John F. Kennedy* (CVN-79) at Huntington Ingalls Industries' Newport News yard, where the lower bow unit was lifted into place in September 2018. The yard gained a c. US$15bn contract to build the third and fourth members of the class at the end of January 2019. *(Huntington Ingalls Industries)*

US NAVY AIRCRAFT CARRIERS AND THEIR AIRCRAFT

In December 2016, the US Navy released a Force Structure Assessment (FSA) that set a goal of achieving a fleet of 355 combatants, including twelve aircraft carriers. In line with this, the FY2018 Defence Authorization Act endorsed a policy that 'It shall be the policy of the United States to have available, as soon as practicable, not fewer than 355 battle force ships …'[1] Since 2006 there has also been a legal requirement – temporarily waived between 2012 and 2017 – that a force of not less than eleven operational carriers be maintained.

Despite this clear policy, the Trump administration's approach to carrier numbers has been somewhat contradictory over the past year. Positively, on 31 January 2019, Huntington Ingalls Industries (HII) was awarded a c. US$15bn contract to build

The US Navy *Nimitz* class carrier *Theodore Roosevelt* (CVN-71) pictured operating in the Gulf of Alaska on 25 May 2019. In spite of orders for new aircraft carriers, the Trump administration's approach to carrier policy has been somewhat contradictory in the face of the development of increasingly powerful anti-access/area denial (A2/AD) weapons by some of the United States' potential adversaries. In particular, there were some indications in the FY2020 budget request that priority is now being given to fielding 'leap ahead' technologies such as unmanned vehicles and energy-directed weapons to the detriment of the US Navy's traditional focus on large carrier-led strike groups. *(US Navy)*

two *Ford* (CVN-78) class aircraft carriers – CVN-80 and CVN-81 – concurrently, a cost-saving concept explained in last year's overview. Once the cost of Government-furnished equipment such as their electromagnetic aircraft launch systems (EMALS) and advanced arrester gear (AAG) are included the two ships are expected to cost about US$25bn, saving some US$3bn to US$4bn compared with the cost if they had been purchased separately. The combined contract allows for better shipyard sequencing, avoids duplication in planning and allows bulk component purchases. Navy acquisition chief James Geurts has stated that the second *Ford* class carrier, *John F. Kennedy* (CVN-79) has already achieved savings of 16 percent compared with the first of the class, *Gerald R. Ford* (CVN-78). The cost differential has been explained by HII's President Jennifer Boykin, who noted that, whilst CVN-78 was a new design with new systems, CVN-79 represented a new way to build an aircraft carrier incorporating digital tools that have allowed the shipyard to sequence work more effectively and reduce labour costs dramatically. The contract for *Enterprise* (CVN-80) and the unnamed CVN-81 is a further development, representing a new way to procure the carriers.[2]

More negatively, the US Navy's record FY2020 budget request for US$205.6bn proved both complicated and controversial when it was announced in March 2019. Rear Admiral Randy Crites, Deputy Assistant Secretary of the Navy for Budget, struck a positive note briefing press representatives by revealing that the US Navy plans to reach the FSA target of 355 ships by 2034. The wider FY2020 defence budget was repeatedly described as the 'masterpiece budget' by Acting Secretary of Defense Patrick Shanahan during his brief time in office, being the first of the Trump administration to reflect policy developments such as the new National Defense Strategy since the president came to power.[3] However, critics have pointed to its incongruities, for example, its aim to increase the overall size of the US Armed Forces whilst reducing funding for some systems in production such as the F-35. In their place, billions of dollars are

Harry S. Truman (CVN-75) pictured transiting the North Atlantic in September 2018. Controversial proposals to cancel her mid-life refuelling that were contained in President Trump's FY2020 US Navy budget were overturned after Congressional pressure. *(US Navy)*

to be spent researching and developing leap-ahead technologies, including unmanned surface and submarine vessels, new manned and unmanned combat aircraft, artificial intelligence capabilities, hypersonic offensive and defensive missiles and directed energy weapons. The urgent search for new technologies comes only a year after the Chief of Naval Operations, CNO, Admiral John M Richardson, stated that transformational weapons should be treated with caution because of their high, unpredictable development costs and their uncertain timescales to delivery.

The most controversial aspect of the proposed US Navy budget was a plan to forgo the refuelling and complex overhaul (RCOH) of the *Harry S. Truman* (CVN-75) in 2024. The total saving could have been as much as US$3.4bn, although only US$17m of that would have fallen in FY2020. The ship's withdrawal at around half its design life when its existing fuel ran out would have permanently reduced the nuclear-powered aircraft carrier (CVN) force and hence carrier availability.[4] Marine General Joseph Dunford, Chairman of the Joint Chiefs of Staff, briefed the House Armed Services Committee, HASC, on 26 March 2019 that '… an important assumption [by the Navy] is that the money saved by not refuelling the *Truman* would be used to develop new ways of conducting maritime strike. So when we look at the carrier, we're looking at it from a maritime strike capability and a more diverse way of providing maritime strike is among the initiatives inside the department.' Lawmakers took immediate exception to the proposal, describing it as 'ridiculous' and 'squandering an asset'. Senator Tim Kaine recalled that the Navy had previously proposed cancelling the RCOH scheduled for *George Washington* (CVN-73) but that it had gone ahead after Congressional pressure, suggesting that the outcome for *Truman* may be similar. These remarks proved prescient. On 30 April Vice-President Mike Pence announced that the carrier would not be retired after all in an address to the ship's crew in her hangar.[5]

Notwithstanding the *Truman* decision and the order placed for CVN-80 and CVN-81, the previous paramount status of the US Navy's nuclear-powered carrier force is seemingly under threat. The Department of Defense is clearly concerned about the vulnerability of CVNs to anti-access/area-denial missiles which out-range the current air wings. However, it is not yet clear how the projected unmanned strike vessels and their array of new weapons represent a better persistent maritime strike capability. There are a number of potential ways forward. In previous years the late Senator McCain's enthusiasm for the concept stimulated discussion about the desirability of a new generation of smaller, CV-type aircraft carriers. After his death, interest seems to have waned. Arguments about the potential savings from cancelling the *Truman* RCOH do raise an interesting point, however, in that they are not far short of the build cost of a *Queen Elizabeth*-type carrier manufactured from the outset with catapults and arrester wires. Such a ship could operate up to sixty aircraft of every type in the US Navy and US Marine Corps (USMC) inventory at an affordable cost and would have the flexibility to embark a marine expeditionary unit (MEU), including its helicopters. If CVNs are now being seen as assets that are too costly to risk, an American *Queen Elizabeth* must surely be worthy of consideration. The build cost of a CVN approximates to three *Queen Elizabeth*s and its RCOH a fourth. The British design's much smaller requirement for manpower also equates to considerable operating savings.

Another way forward was postulated by the US Center for Strategic and Budgetary Assessments (CSBA) in a frank report entitled *Regaining the High Ground at Sea* published in December 2018.[6] It describes current carrier air wings as containing aircraft with relatively short range but relatively high payload that were appropriate for the immediate post-Cold War era but are not necessarily suited to keeping the carrier safe from a growing range of missile threats from 'near peer' adversaries. The report's assessment is that carriers might need to stay as far away as 1,000 nautical miles from potential targets, significantly beyond the realistic radius of action of current carrier aircraft. The suggested answer is to change the balance of the planned carrier air wing (CVW) of the future towards longer-range unmanned combat air vehicles (UCAVs) capable of operating at 1,000 nautical miles or more from their parent carrier. Although development of the currently planned MQ-25A Stingray as an in-flight refuelling aircraft would continue for the time being this would be evolved to become a more multi-mission capable aircraft pending introduction

of an entirely new UCAV. Meanwhile F-35C production would be truncated in the mid-2020s in favour of a new long-range F/A-XX manned fighter better capable of coping with the distances required to be effective in a conflict in the Western Pacific.

Meanwhile, problems setting to work the complex systems in the *Gerald R. Ford* continue to impact the extent of her 'post-shakedown' refit and, hence, delay to her entry into operational service. Reportedly, none of her eleven weapons elevators were functional in early 2019, leading Secretary of the Navy, Richard V Spencer, to tell President Trump in January to fire him if they were not fixed by summer.[7] The first weapons elevator was declared operational in January 2019 followed by a second in February, giving one forward and one aft. Lessons learned were then applied to the remaining nine. However, the US Navy has admitted that when *Ford* leaves Newport News the majority of the elevators will still not be usable. A land-based test site is being constructed to help speed resolution of this problem. Moreover, in March, Geurts informed the HASC that technical problems with the ship's main turbine-generators will require an extensive overhaul that will delay the carrier's return to the fleet to October 2019 at the earliest. Colleen O'Rourke, a spokeswoman for the Naval Sea Systems Command, briefed that the propulsion system issue was associated with a recent design change and the builder is working closely with the Navy to re-evaluate the delivery date. More positively, by the end of 2019 the Navy hopes to have all the technical data it needs to launch and recover every configuration of the F/A-18E/F and EA-18G from *Ford.* Once the carrier is at sea again, test pilots will carry out validation landings to add to the 763 landings that have already been carried out. The carrier's new EMALS and AAG are intended to boost its sortie generation rate by as much as a third over the *Nimitz* class whilst reducing maintenance manpower.

The second *Ford* class carrier *John F. Kennedy* was structurally over 80 percent complete at the end of 2018 after the lift of the final piece of her underwater hull – a 726-ton lower bow section – into place on 28 September 2018. Christening and launch is scheduled before the end of 2019.

Cost caps imposed by Congress on the first two *Ford* class carriers to keep their price from escalating has led the US Navy to plan to accept them without the capability to support the F-35C Lightning II variant on a full deployment. The intention is to carry out the necessary modifications – including the addition of classified spaces and the installation of more robust jet blast deflectors – during post-delivery maintenance periods. The House Armed Services seapower and projection subcommittee has taken a dim view of the fact the new carriers will be incapable of fully supporting the service's most advanced fighters and has proposed prohibiting the US Navy from accepting CVN-79 until it can deploy with F-35Cs. At the moment, only *Abraham Lincoln* (CVN-72) amongst the carriers is properly equipped for the F-35C. The first F-35C squadron, Strike Fighter Squadron 147 (VFA-147), is expected to embark aboard the *Carl Vinson* (CVN-70) in 2021 and this ship is at present in Puget Sound Naval Shipyard for a planned incremental upgrade availability to permit their deployment.[8]

Boeing's MQ-25A Stingray unmanned aerial tanker prototype, known as T1, seen undergoing ground testing at the company's St. Louis site in early 2018. It is expected to make its first flight before the end of 2019. In August 2018 the US Navy signed a contract with Boeing for the initial four of what could eventually be a total of seventy-six aircraft. *(Boeing)*

Even without the emphasis on leap-ahead technology outlined in FY2020, the US Navy already has advanced aircraft projects underway that few other nations could afford. In August 2018 the Navy signed a contract with Boeing to cover '… the design, development, fabrication, test, verification, certification, delivery and support of four MQ-25A unmanned air vehicles including integration into the carrier air wing to provide an initial operational capability to the Navy'. Geurts briefed media representatives that the US Navy intends to achieve the MQ-25A Stingray's initial operational capability (IOC) on carrier decks in 2024, earlier than previously thought possible. The first airframe will be flying by 2021. Early aircraft will be used for engineering and manufacturing development and the Navy eventually plans to procure seventy-two more at a total programme cost of c. US$13bn. Before IOC, the Navy needs to complete air vehicle carrier suitability testing, modify carriers with control stations, train maintainers and operators, and create a logistics chain. Boeing has already built a prototype to expedite the project and the Navy's unusual step of including only two key parameters in its statement of requirement has helped to hasten it forward. These are mission tanking and carrier suitability, reflecting the desperate need for a new tanker given up to a third of Super Hornet flight hours are currently devoted to aerial refuelling rather than their primary strike fighter role.

Admiral Richardson has briefed that the contract with Boeing is important for two reasons; the operational impact on carrier operations and the acquisition lessons that can be applied to other new, technologically-advanced projects. The acquisition process had helped the Navy '… make the biggest leap possible with the confidence in the maturity of

A graphic of the latest Block III variant of the US Navy's F/A-18E Super Hornet. Seventy-eight of these aircraft were ordered in March 2019 for delivery from 2020 onwards. The Block III configuration adds upgrades that include enhanced network capability, longer range, reduced radar signature, an advanced cockpit system and an improved communication system. Boeing will also begin converting existing Block II Super Hornets to Block III configuration early in the next decade. *(Boeing)*

A C-2A Greyhound carrier-on-board delivery aircraft being prepared for take-off from the US Navy's *Abraham Lincoln* (CVN-72) in April 2019. The FY2020 budget request continues to request procurement of replacement CMV-22B Osprey tilt rotors, with the first of the new aircraft scheduled for delivery in the course of 2020. *(US Navy)*

the technology, so we can do cost and schedule with more confidence than before'. Richardson believes that there might be opportunities to advance IOC further but much learning is still required before the full implications for cyclic operations, endurance and the use of unmanned tankers are fully understood. Geurts added that the decision to use the government as programme integrator will make it easier to add intelligence, surveillance and reconnaissance capabilities to the MQ-25 if the US Navy chooses to do so.

Until the first F-35C squadron deploys with a carrier air wing, the F/A-18E/F Super Hornet is the only US Navy carrier-borne strike fighter. However, at the start of 2018 significantly less than half the fleet was fully mission-capable, largely because of budget cuts in logistic support associated with sequestration – a problem common to all US Navy, Marine Corps and Air Force tactical aircraft. Before he resigned, Secretary of Defence Jim Mattis noted that these budget constraints had caused '… our aviation inventory and supporting infrastructure to suffer from systemic underperformance, overcapitalisation and unrealised capability'. He called for a minimum 80 percent mission capable rate to be achieved for four key tactical aircraft inventories – the F-16, F-18, F-22 and F-35 – by the end of FY2019. By April 2019 good progress towards this goal had been achieved with availability rates of up to 75 percent and the US Navy was confident the goal would be soon reached and exceeded.[9]

The Navy asked logistics specialists and airlines to evaluate Super Hornet maintenance and spares support and their response was striking. Rear Admiral Scott Conn, the US Navy's Director of Air Warfare briefed the HASC that maintenance periods have fallen from 120 to 60 days and improved logistic training has resulted in items that had taken a month to despatch now arriving in two days. Fighter repairs are now scheduled and completed in a predictable timeframe and aircraft are operational within three days of maintenance.

Table 4.1.1: US NAVY PLANNED AIRCRAFT PROCUREMENT: FY2018–FY2023

TYPE	MISSION	FY2019 Authorised[1]	FY2020 Requested	FY2021 Planned	FY2022 Planned	FY2023 Planned	FY2024 Planned	FYDP Planned[2]
Fixed Wing (Carrier-Based)								
F-35B Lightning II JSF	Strike Fighter (STOVL)	22 (20)	10	15	17	20	20	**82 (101)**
F-35C Lightning II JSF	Strike Fighter (CV)	15 (9)	20	18	29	27	26	**120 (97)**
FA-18E/F Super Hornet	Strike Fighter (CV)	24 (24)	24	24	12	12	12	**84 (110)**
E-2D Advanced Hawkeye	Surveillance/Control	6 (4)	4	4	5	5	0	**18 (24)**
Fixed Wing (Land-Based)								
P-8A Poseidon	Maritime Patrol	10 (10)	6	0	0	0	0	**6 (19)**
C-40A Clipper	Transport	2 (2)	0	0	0	0	0	**0 (2)**
KC-130J Hercules	Tanker	2 (2)	3	5	5	5	3	**21 (23)**
T-44 Replacement[3]	Training	0 (0)	0	0	0	10	20	**30 (10)**
F-5 Tiger II[4]	Training	0 (0)	22	0	0	0	0	**22 (0)**
Rotary Wing								
AH-1Z Viper	Attack	25 (25)	0	0	0	0	0	**0 (25)**
VH-92A	Presidential Transport	6 (6)	6	5	0	0	0	**11 (17)**
CH-53K King Stallion	Heavy-Lift	8 (8)	6	12	19	18	19	**74 (69)**
C/MV-22B 22 Osprey	Transport	13 (6)	10	9	11	8	4	**42 (52)**
TH-57 Replacement[5]	Training	0 (0)	32	31	31	15	0	**109 (85)**
Unmanned Aerial Vehicles								
MQ-25A Stingray	Refuelling	0 (0)	0	0	0	4	4	**8 (4)**
MQ-4C Triton	Maritime Patrol	3 (3)	2	2	3	5	5	**17 (17)**
Totals:		**136 (120)**	**145**	**130**	**132**	**129**	**113**	**644 (655)**

Notes:

1. FY2019 authorised numbers reflect numbers actually funded in the Consolidated Appropriations Act signed into law on 28 September 2018; figures in brackets reflect aircraft numbers set out in the Trump Administration's Presidential Budget Request of 12 February 2018 As is frequently the case, the US Congress added material numbers of aircraft over the original request.
2. FYDP (Future Years Defense Program) for 2020–4 as at time of FY2020 Presidential Budget Request with last year's FYDP numbers for FY2019–23 in brackets. The overall trend is a marked downturn in planned procurement, particularly of front-line combat aircraft.
3. Refers to replacement of the T-44 Pegasus (Beechcraft King Air series) twin-engine turboprop trainer.
4. Refers to acquisition of surplus F-5 aircraft from Switzerland for refurbishment to act as 'aggressor squadron' aircraft in the combat training role.
5. Refers to replacement of the TH-57 Sea Ranger (Bell 206 series) training helicopter.

Looking forward, the US Navy is making progress in bringing into service the latest Block III Super Hornet iteration, which will comprise a mix of new-build and upgraded aircraft. In March 2019 the Navy awarded Boeing a c. US$4bn contract to build seventy-eight new Block III Super Hornets in a multi-year deal that will last until FY2021 and cost US$395m less than smaller, single-year batches would have done.[10] The latest Aviation Procurement Plan summarised in Table 4.1.1 slightly slows overall new Block III procurement compared with previous plans but the decision to build the last six Super Hornets in the FY2018 production as Block III variants should mean the new type starts coming off the production line from late 2020. Additional aircraft will be modernised under the Super Hornet Service Life Modification (SLM) programme described in detail in *World Naval Review 2019*, which now aims to transition to delivering upgraded Block III Super Hornets as part of the SLM in the course of 2022.

More detail is also emerging about the extent of the Super Hornet Block III upgrades. In November 2018 Lockheed Martin was awarded a contract to complete development of its IRST 21 infrared search and track sensor, which is to be mounted internally (later Block II aircraft had an earlier version mounted in the nose of a belly-mounted external fuel tank). It enables fighters to gain passive contact on targets at long range without giving away their own presence with radar transmissions. A new advanced cockpit display system improves pilot situational awareness and the tactical targeting network technology (TTNT) data link enables sensor fusion among multiple aircraft. Block III development flights with TTNT and distributed targeting processor network (DTPN) computers have demonstrated data fusion in near real time in multiple aircraft, giving a common tactical picture and weapon-engagement quality tracks at unprecedented ranges.

Whilst the Super Hornet has a long future ahead of it, the legacy F/A-18 Hornet is now entering the terminal phase of its operational service with the US fleet. In February 2019 the last deployable US Navy F/A-18C/D unit, the 'Blue Blasters' of Strike

Fighter Squadron 34 (VFA-34), retired their aircraft and began conversion onto the Super Hornet. The US Navy's 'Blue Angels' flight demonstration team is also to replace its legacy Hornets with Super Hornets from 2021, with nine Block 1 F/A-18E and two Block I F/A-18F Super Hornets being modified to the appropriate configuration under a US$17m contract awarded in August 2018.[11] However, the US Marine Corps continues to operate eleven Hornet squadrons and, under current plans, will not complete transition to its replacement F-35Cs until 2030.

The US Navy's replacement programme for the aging C-2A carrier on-board delivery (COD) aircraft also advanced in July 2018 with a multi-year contract that includes thirty-nine CMV-22B Osprey COD aircraft for the Navy. Admiral Conn briefed a HASC Seapower and Projection Forces subcommittee meeting in late 2018 that the Osprey was being introduced as fast as possible with the first due for delivery in 2020. Development flying is minimised by the new variant's similarity to the Marines' MV-22B and naval aircrew have already begun training with the USMC. This has allowed the first US Navy Osprey squadron, VRM-30 the 'Titans', to be commissioned in December 2018 at San Diego. Vice Admiral de Wolfe H Miller, Commander Naval Air Forces, attended the ceremony and said that the CMV-22B '… is our future and when you look at the nature of the future fight, we need that versatility, that flexibility that is going to be provided in every subsequent squadron that transitions'.

OTHER AIRCRAFT CARRIER OPERATORS

UNITED KINGDOM

On 25 September 2018 Commander Nathan Gray RN carried out the first fixed-wing landing on the aircraft carrier *Queen Elizabeth*, marking a clear step towards the restoration of a British strike carrier capability. The aircraft was one of two F-35Bs from the F-35 Integrated Test Force (ITF) based at Naval Air Station Patuxent River, Maryland. Three other

On 25 September 2018 Commander Nathan Gray RN carried out the first fixed-wing landing on the aircraft carrier *Queen Elizabeth* at the start of a period of tests off the United States' eastern coast. Two F-35B Lightning II jets from the F-35 Integrated Test Force (ITF) based at Naval Air Station Patuxent River, Maryland carried out an extensive period of trials over a period of nearly two months. *(Crown Copyright 2018)*

pilots were embarked, RAF Squadron Leader Andy Edgell, USMC Major Michael Lippert and civilian test pilot Peter Wilson. Two test periods designated DT-1 and DT-2 were carried out off the east coast of the United States and successfully completed on 18 November having carried out 202 take-offs, 187 vertical landings and 15 ship rolling vertical landings (SRVL). The latter is a technique unique to British F-35B operations intended to use low-speed wing lift to permit landings at higher weights than would be possible with vertical recoveries, allowing unused weapons to be brought back. DT-2 sought rougher sea conditions to provide data for an expanded F-35B operating envelope and the four embarked pilots carried out fifty-four weapon drops to test loading and operating procedures. Most sorties were of short duration and a total of 75 flying hours were achieved in trials described by the ship's new commanding officer, Captain Nick Cooke-Priest RN, as having been challenging but successful beyond expectation.[12]

The RN took the opportunity to gain as much operational value as it could from the deployment, designated 'Westlant 18'. *Queen Elizabeth* had already achieved IOC as a helicopter carrier and embarked Merlin HM 2s of 820 Naval Air Squadron (NAS) plus Merlin HC 4s of 845 NAS as task force assets. The Commander UK Carrier Strike Group (COMUKCSG), Commodore Andrew Betton RN, was on board with most of his battle-group staff and *Queen Elizabeth* also embarked Royal Marines of 42 Commando and personnel from a deployable medical team. The carrier saw visits from the USMC's MV-22B Osprey and the US Navy's MH-53E Sea Dragon during the course of the deployment.

On return to the UK, *Queen Elizabeth* began a period of capability upgrades and returned to Rosyth for a docking and hull survey. Ship upgrades included installation of the Phalanx Block 1B close-in weapons system. She is due to undertake another period of fixed-wing trials off the eastern United States during the second half of 2019. This will be followed by an operational readiness inspection (ORI) in late 2020 which is expected to culminate in the declaration of IOC for carrier operations. However, full strike carrier operational capability is not expected until 2023. By then the second operational F-35B squadron, 809 NAS, is due to have been commissioned.

Queen Elizabeth's sister-ship *Prince of Wales* was nearing completion in mid-2019, with the bridge handed over to the RN in March. The ship's systems ran on internal power in late 2018, marking the beginning of harbour acceptance trials. Sea trials are due to commence in late 2019 with formal commissioning into the RN due in early 2020. Meanwhile, the first British operational F-35B unit, the jointly RAF/RN-manned 617 Squadron, reached IOC for land-based operations at the end of 2018. By the beginning of 2019, 26 British pilots had qualified to fly the F-35B in the USA and a training unit, 207 Squadron, was in the process of forming at the F-35's base at Marham. It is expected to officially stand up on 1 July 2019.

A F-35B Lightning II pictured on the flight deck of the Royal Navy aircraft carrier *Queen Elizabeth* at the start of the 2018 fixed-wing trials. Two test periods – DT-1 and DT-2 – were concluded in November 2018, paving the way for a more ambitious set of trials towards the end of 2019. *(Crown Copyright 2018)*

In November 2018, the then British Defence Secretary Gavin Williamson announced that seventeen more F-35Bs had been ordered for delivery between 2020 and 2022 to equip 809 NAS and the training unit at Marham. They formed part of an order for 255 F-35s of all three variants for the US and global customers. The agreement took total British orders to thirty-five F-35Bs out of a government-confirmed initial purchase of forty-eight aircraft. Whilst it has repeatedly stated that a total of 138 F-35s will eventually be procured 'through the life of the project', it has not committed to the variant that will comprise the balancing nienty. Indeed, there have been media reports of senior RAF officers voicing a preference for the F-35A land-based variant, leaving only forty-eight 'B' models for carrier operations. Lord West, the former First Sea Lord, is one of many saying that it makes little sense to procure aircraft that cannot be deployed at sea but it seems that there are still those in the RAF who retain a culture of trying to prevent aircraft being used under any control but their own.

The last Sea King ASaC 7 helicopters of 849 NAS were withdrawn from service in September 2018, marking the end of the type's 49 years of service in the RN. The replacement is a developed version of the ASaC 7's Cerberus mission system with its associated Searchwater radar, procured under Project 'Crowsnest' as role equipment which can be fitted to Merlin HM 2s as an alternative to anti-submarine warfare (ASW) role equipment. Target IOC is set for 2020, in line with that for *Queen Elizabeth*. Compared with the legacy system, it has new radar modes, more extensive Link 16 data transfer capability and increased track numbers. Ten Cerberus sets are being procured with about seven to be fitted to 849 NAS Merlins at any one time. In theory, role changes can be carried out quickly whilst embarked

France's newly refuelled and modernised *Charles de Gaulle* departed Toulon for the Indian Ocean in March 2019 under the auspices of 'Mission Clemenceau 2019'. She is pictured here operating with US Navy forces in the Red Sea on 15 April 2019. *(US Navy)*

using the spare sets but the frequency with which changes will actually be made is conjectural. There are only thirty HM 2s and the subtraction of seven from that number on a regular basis leaves only twenty-three for service in the ASW role with 820 and 814 NAS in the two carriers, RFAs and ASW frigates plus the training unit, 824 NAS at Royal Naval Air Station Culdrose. If fewer were fitted with Cerberus, ASaC skills would atrophy and the fleet would find it difficult to maintain this vital capability. Put bluntly, thirty Merlin HM 2s is too small a number to carry out all the operational requirements expected of them.

FRANCE

Aeronavale Rafale M fighters embarked in both *George H. W. Bush* (CVN-77) and *Harry S. Truman* (CVN-75) in the course of 2018, working up for re-embarkation in France's *Charles de Gaulle* and demonstrating their ability to operate seamlessly with a close ally. The French ship completed a mid-life *arrêt technique majeur* – broadly similar to a RCOH – in November 2018 prior to departing Toulon in March 2019 for 'Mission Clemenceau 2019', a five-month deployment to the Indo-Pacific region. Whilst in the Mediterranean, she carried out strikes against Islamic extremists in Syria. She subsequently conducted a number of multilateral and bilateral exercises with allied navies in May before sailing to Singapore to be present at the annual 'Shangri-La' Asian security summit, demonstrating the political value of naval presence in the region.

Charles de Gaulle's air wing usually comprises twenty-four Rafale Ms, two E-2C Hawkeyes and four combat SAR helicopters, although the number of Rafales embarked can surge to thirty if necessary. The French Navy operates three squadrons of Rafale M omni-role fighters – 11F, 12F and 17F – based at Landivisiau near Brest to support carrier deployments. January 2019 saw the Navy take delivery of its first Rafale M upgraded to the latest F3R standard, which includes integration of the MBDA Meteor long range air-to-air missile, the laser homing version of the Safran air-to-ground modular weapon and the Thales Talios laser-designator pod. All Rafales delivered since 2013 have also been equipped with RBE-2 active electronically-scanned array (AESA) radar. Data can be shared with *Aeronavale* E-2Cs and other Rafales using Link 16 and launch and deck landing are simplified by automated systems intended to reduce pilot workload.

After catapult launch an automatic mode puts the aircraft into a nose-up attitude until it is climbing safely away from the sea. On recovery an auto-throttle system keeps the aircraft at a constant speed – 124 knots in the case of a clean Rafale – at an angle of attack of 16 degrees. Head-up display symbology allows the pilot to place a marker on the exact touch-down point his aircraft will achieve. The French have never accepted stealth as the best method of penetrating contested air space, believing that it places too great a restriction on aircraft design and that sensors will inevitably be developed to limit its value. Instead, both Air Force and Navy Rafales penetrate contested air space using extreme low-level, terrain-following tactics prior to launching stealthy stand-off weapons such as the SCALP cruise missile against pre-planned targets.

The French Navy has already begun to study the requirement for a future aircraft carrier to replace *Charles de Gaulle* under a programme formally launched by French Defence Minister Florence Parly at the Euronaval trade fair in October 2018. According to Laurent Sellier, head of the naval element within France's *Direction Generale de l'Armament* (DGA), an initial work stream has focused on operational requirements, including the new ship's ability to operate the Rafale and its likely successors.[13] A second study, also led by the DGA, is focusing on technology and the ship's digital systems architecture. Key ship factors will include size, aircraft operating systems and the choice between nuclear and conventional propulsion. French defence giant Thales is likely to be able to contribute experience from its work within the British Aircraft Carrier Alliance. A decade ago the French purchased the right to use the *Queen Elizabeth* design as the basis of a future carrier option.

INDIA

The Indian Navy (IN) currently has a single carrier, the former Russian *Admiral Gorshkov* now renamed *Vikramaditya*, in service. A second, *Vikrant*, is under construction in India and expected to enter service sometime after 2020. Both are STOBAR (short take off but arrested recovery) designs. However, a projected second indigenous aircraft carrier (IAC-2) – provisionally named *Vishal* – is seen as a larger, 65,000-ton ship with catapults and arrester wires. It is seen as being able to operate up to fifty strike fighters, with either Boeing's F/A-18E/F Super Hornet or the French Rafale M being seen as the likely main component of its air wing. The IN is seeking an international industrial partner to facilitate the realisation of this project.

The US Government has offered to make EMALS and AAG available to India and recent media reports suggest the IN is considering fitting these to a modified *Queen Elizabeth* class carrier design offered by BAE Systems. At c. 65,000 tons it seems a good match with the Indian requirement and considerable work was put into fitting EMALS and AAG into the design after the British Government temporarily decided to adopt them in 2010. In early 2019 the Chief of the Indian Naval Staff, Admiral Sunil Lanba, visited the United Kingdom for discussions with the First Sea Lord, Admiral Sir Philip Jones, viewing progress with the *Queen Elizabeth* class programme. The signature of a carrier capability partnership agreement paved the way for the Royal Navy to share the experience it has gained from the project. However, there is considerable uncertainty as to whether the IN can afford to progress IAC-2 at the current time, whilst a number of other potential suppliers are also touting alternative proposals. As such, any expectation of an imminent deal is likely premature.

CHINA

Over the last year there have been several reports commenting that the People's Liberation Army Navy Air Force (PLANAF) is dissatisfied with its current carrier-based strike fighter, the Shenyang J-15 Flying Shark. In addition to an apparently poor radius of action derived from limitations on its maximum weight when using the ski-jump launch technique, flaws in its flight control system have made deck landings difficult and caused a number of crashes. Notably, some Chinese media sources have disparagingly referred to it as the 'Flopping Fish'. The PLANAF urgently wants a replacement, reportedly the next generation Shenyang J-31. Broadly comparable to the F-35C, the J-31 is reportedly somewhat lighter than its predecessor with a maximum take-off weight of c.62,000lbs. Two RD-92 93 afterburning turbofans each provide 19,000lbs (85kN) of thrust to provide a maximum speed in level flight of around Mach 1.8. Radius of action is said to be 675 nautical miles and sensors include a KLJ-7A AESA radar, electro-optical targeting system and a distributed aperture system.

China's second aircraft carrier – the indigenous Type 001A variant of the existing *Liaoning* – has spent the last year undertaking periodic sea trials, departing on its sixth voyage towards the end of May 2019. It is expected to achieve IOC by the end of the year. Less has been heard about the follow-on Type 002 carrier, which is expected to be a conventional catapult assisted take-off but arrested recovery (CATOBAR) design. There have been some reports that work on the project was paused in late 2017 while design development of a Chinese EMALS was finalised at the Huludao test site. However, the Washington DC-based Center for Strategic & International Studies' (CSIS) *ChinaPower* website posted imagery on 6 May 2019 apparently showing work on the ship well underway at the Jiangnan Shipyard the previous month.[14] With work on the programme resumed, the c. 80,000–90,000-ton carrier could be launched before the end of 2020 and join the operational fleet by 2023. This would, however, be a tight timescale for a complex ship.

ITALY

The Italian Navy continues to operate a force of AV-8B+ Harriers known as *Gruppo Aerei Imbarcati*, or *Grupaer* for short, from Naval Air Station Grottaglie near Taranto. They embark regularly on Italy's largest carrier, *Cavour*, and also periodically on the smaller and older *Giuseppe Garibaldi*, which is also serving as an amphibious assault ship prior to her planned retirement in 2022. Pilots are trained in America on the AV-8B with Marine Attack Training Squadron 203 (VMAT-203) at Marine Corps Air Station (MCAS) Cherry Point, North Carolina and Italian aircraft are sent to Cherry Point for their deep maintenance and planned upgrades. Software upgrades are aligned with those of the USMC and Spanish Navy, the latest being H7.0 which introduces Link 16.

The Italian Navy has ordered fifteen F-35Bs, reduced from an originally planned twenty-two. All will be manufactured on the Italian assembly line at Camieri. The first, MM7451, flew to the USA for electromagnetic compatibility tests in 2018 after which it is being used to train Italian pilots and maintenance personnel with VMFAT-501 at MCAS Beaufort, South Carolina. The first three Italian aircraft are to be based at Beaufort until 2020, when they will return to Italy. However, it is not yet clear whether they are to be based at Grottaglie or co-located with the Italian Air Force's F-35A/B fleet to share facilities. Before *Cavour* can operate F-35Bs she needs modifications including deck insulation to

A pilot attached to the Italian Navy's *Grouppo Aerei Imbarcati* (*Grupaer*), climbs out of an Italian Navy AV-8B Harrier II Plus after landing on the flight deck of the *Wasp* class amphibious assault ship *Iwo Jima* (LHD-7) in July 2018. *Marine Militare* Harrier pilots are trained alongside their USMC counterparts in North Carolina and their aircraft's software is upgraded in line with that installed in American and Spanish Harriers. *(US Navy)*

cope with the heat from the 'B's exhaust, re-routing of pipes and cables under the flight deck, the installation of new mission-planning software and the Autonomic Logistics Information System (ALIS). It is anticipated that IOC will be achieved in the early 2020s, when *Cavour* should be capable of embarking up to twelve F-35Bs at any one time.

SPAIN

The Spanish Navy's 9th *Escuadrilla* also continues to operate AV-8B+ Harriers. They are shore-based at NAS Rota but embark regularly in the amphibious assault ship *Juan Carlos I,* which doubles as a substitute carrier. Requirements for deep maintenance and upgrades are dovetailed with the USMC and Italy. This makes the most out of a shrinking overall Harrier fleet as the USA and Italy replace their aircraft with F-35Bs. Spanish Harriers are expected to reach the end of their fatigue lives in about 2030, when they will probably be the last examples in service. The remaining AV-8Bs are broadly comparable with their Italian and US counterparts, with H7.0 software being installed by 2020 to keep the Spanish Navy's small force effective. The only viable replacement is the F-35B and *Juan Carlos I* was designed with its operation in mind but there is, as yet, no confirmed plan for the Navy to procure it.

RUSSIA

The Russian Navy's only aircraft carrier, *Admiral Kuznetsov*, was damaged in October 2018 when the dry dock in which it was being refitted sank after an electrical malfunction led to pumps over-filling the dock's ballast tanks. A large crane crashed onto the flight deck causing a gash of about 16ft (5m). Whilst there were reports that the ship has been moved to another shipyard to complete the work, the head of

The Italian aircraft carrier *Cavour* will be adapted to operate F-35B Lightning II strike fighters in replacement for her existing Harriers. This will include modifications to her flight deck to accommodate the severe heat from the F-35B's exhaust. *(Fincantieri)*

the United Shipbuilding Corporation apparently told the TASS state news agency that there is no alternative dry dock big enough for *Kuznetsov*. Deputy Prime Minister Yuri Borisov was reported as saying that refloating the dry dock was likely but could take six months. Subsequent refurbishment could last months or even years. *Kuznetsov* is already an elderly warship with obsolescent systems and her future now appears somewhat uncertain.

AMPHIBIOUS AND HELICOPTER CARRIERS

On 18 December 2018 the Japanese Government confirmed previous speculation by announcing that the two large 'helicopter-carrying destroyers' *Izumo* and *Kaga* would be modified to operate F-35B Lightning II strike fighters. Japan also announced the acquisition of a further 105 F-35s, bringing total Japanese procurement to 147. Forty-two of these are to be F-35Bs for the Japan Maritime Self-Defence Force (JMSDF). The defence ministry plans to procure eighteen F-35Bs in the five fiscal years from 2019 to 2023 to be followed by twenty-four more after 2023. Local assembly of the aircraft at Nagoya will be terminated as a result of the high price of early Japanese production aircraft, the plant being switched to maintenance. The time-scale for modification of the two 'multi-purpose operation destroyers' has not been announced.

It seems that South Korea does not want to be left behind by Japanese developments. The Yonhap News Agency reported in September 2018 that the South Korean Navy had ordered studies into the potential operation of F-35Bs from its amphibious assault ships *Dokdo* and *Marado*; the latter of which is still under construction. *Dokdo*'s deck was only designed for helicopter operations and she would need extensive modification to withstand both the weight and heat of the F-35B operations. Suitable mission planning, simulation and communications systems would also need to be provided. By contrast, *Marado* has a stronger deck and would probably require less time, work and funding to modify her into a true multi-purpose light carrier.

Japan's decision to modify its *Izumo* class destroyers into light aircraft carriers has also rekindled debate in Australia about whether to modify its two *Canberra* class amphibious assault ships into multi-purpose light carriers. The ships are based on the *Spanish Juan Carlos I* and actually have 'ski-jumps' but were not fitted during build with the

A view of the JMSDF 'helicopter-carrying destroyer' *Izumo* (DDH-183) operating with the destroyer *Akizuki* (DD-115) and the dock landing ship *Shimokita* (LST-4002) provides some indication of the size of the ship and, hence, its suitability for fast jet operation. In December 2018 the Japanese government confirmed that it intended to acquire F-35B STOVL strike fighters to operate from *Izumo* and her sister *Kaga* (DDH-184). *(JMSDF)*

The Royal Australian Navy's amphibious assault ship *Adelaide* seen conducting a replenishment at sea with Royal Canadian Navy supply ship, MV *Asterix*, during Exercise RIMPAC 18. The *Adelaide*'s original Spanish design was based on a requirement to support STOVL operations and she is fitted with a ski-jump, therefore facilitating maritime fast jet operations should Australia decide to acquire the Lightning II F-35B variant. *(Royal Australian Navy)*

Two images of Brazil's helicopter carrier *Atlântico*, the former British *Ocean* transferred in June 2018, during flying exercises in the South Atlantic in January 2019 as part of the 'Aspirantex' training and familiarisation deployment. *(Brazilian Navy)*

internal arrangements needed to support strike fighters. They could, however, be modified to have them, whilst the Japanese decision means there is increased potential for inter-operability if F-35Bs were to be procured for the Royal Australian Navy (RAN) to operate at sea. Australia's most significant allies, the United States, the United Kingdom and Japan all now either deploy embarked F-35Bs into the region or have announced their intention to do so, giving considerable scope for maritime co-operation. Importantly, they are not just fighters but would act as sensor nodes in networked-enabled, distributed-lethality operations over vast areas of sea, providing weapons grade data for other platforms as well as extending their range. Viewed from this perspective, the question is not whether the RAN would benefit from an embarked force of F-35Bs but whether it can operate effectively alongside its allies without them.

October 2018 saw the start of fabrication on *Bougainville* (LHA-8), the latest US Navy amphibious assault ship. She differs from the first two ships of the class – *America* (LHA-6) and *Tripoli* (LHA-7) – in incorporating the new Enterprise Air Surveillance Radar (EASR) and, most significantly, reverting to the well-deck found in earlier US Navy assault ships. With carrier strike groups now considered vulnerable to A2/AD threats up to 1,000 nautical miles from a hostile coast, the use of landing craft that must – of necessity – be launched close to the shore seems an anachronism that is difficult to justify. Moreover, in other respects the USMC seems to be shifting its focus away from opposed landings towards operations that support sea control, sea denial and power projection. Much of this is being driven by the additional capabilities provided by the arrival of the F-35B. The last year has seen two amphibious assault ships, *Essex* (LHD-2) and *Wasp* (LHD-1), embark operational F-35B squadrons, the former's seeing the F-35B undertake its first combat missions whilst deployed in the Middle East. From 2020, MV-22s modified with the VARS aerial refuelling system will allow a significant improvement in the F-35B's radius of action from an amphibious assault ship and more time on specific tasks.

The move towards dispersed lethality and unmanned systems has focused USMC attention on its lack of airborne early warning (AEW) assets. This is a capability gap it wants to fill as quickly as possible now that amphibious carriers are being re-equipped with F-35Bs and, when operating with

Aegis-equipped surface vessels, also have access to high-end radars and have the networks to link them. Unable to embark the Navy's E-2D Advanced Hawkeye, the Marines want to fill the gap with the Marine Air-Ground Task Force Unmanned Aerial System or MUX. In 2019 Brigadier General James Adams, director of capabilities at Marine Corps HQ, described AEW as the primary MUX capability to allow greater lethality in distributed maritime operations whilst amphibious assault ships are operating separately from the carrier strike groups. MUX is now seen as the key integrator of marine forces fighting at sea and when moving ashore, able to cue every weapon available in the co-operative engagement capability network and in the Naval Integrated Fire Control-Counter Air (NIFC-CA) system of systems. Adams expects MUX to operate for about eight hours at 350 nautical miles from a ship at a speed of around 200 knots. Deputy Commandant for Aviation, Lieutenant General Steven Rudder, envisages MUX as being about the size of the MQ-9 Reaper or MQ-1 Predator with a 'footprint on deck similar to a UH-1 helicopter, the ability to fit into a destroyer hangar and costing about U$22m each'. He plans to 'go fast' with MUX in 2020, '… assuming that there is technology there that allows us to'. An analysis of alternatives is to take place in 2019, followed by prototype testing and selection of a vehicle for production.[15]

Meanwhile, the USMC's CH-53E Super Stallion heavy-lift helicopter fleet has undergone a significant improvement in serviceability over the past year following a maintenance 'reset' programme which refurbished 22 out of the fleet of 141 aircraft. The Corps now aims to keep them in service until 2031 or beyond. The replacement CH-53K King Stallion has, however, encountered 'late technical issues' which will delay its IOC, originally scheduled for 2019. It may well not be deployed before 2024. In spite of these problems, the Marine Corps appears to retain faith in the design, with a US$1.1bn contract for an additional twelve machines under productions lots 2 and 3 inked in May 2019. Current plans envisage 200 CH-53Ks being acquired.

Brazil's new amphibious helicopter *Atlântico*, the former Royal Navy *Ocean*, arrived in Rio de Janeiro at the end of August 2018 and was transferred to the operational fleet the following month. It has subsequently been undergoing an extended period of trials and work-up. It has been reported Mistral point defence missile systems are being fitted to replace the Phalanx systems removed before her transfer.

A F-35C Lightning II from the 'Argonauts' of Strike Fighter Squadron (VFA) 147, completes a flight over Eglin Air Force Base, Florida in February 2019. All three Lightning II variants have now achieved IOC and the aircraft has seen combat with both the Israeli Air Force (F-35A variant) and the US Marine Corps (F-35B variant). *(US Navy)*

F-35B/C LIGHTNING II JOINT STRIKE FIGHTER: THE GAME-CHANGER

The last year has been a significant one for the F-35 Lightning II joint strike fighter. All three versions have now achieved IOC and are deployed with operational squadrons within their respective US services; the type has been used in action for the first time, overseas customers, including the United Kingdom, have operational aircraft and – less positively – the first F-35s have been lost in accidents.

The F-35 evolved from the fusion of a number of US fighter and attack aircraft projects in the late 1980s. Its single-engine, single-pilot configuration was largely driven by the requirement to incorporate a STOVL variant in the programme in addition to those aircraft intended for 'conventional' navy and air force operations. Originally conceived as low-cost strike aircraft capable of overcoming the generation of air defences coming into service at the turn of the century, development expenses escalated after the incorporation of capability enhancing, software-controlled electronics. Defence analyst Norman Friedman has observed that, unlike contemporary hardware development costs which can be predicted with some accuracy, software costs have proved impossible to forecast. Indeed, the F-35 is an outstanding example of 'runaway' software development costs. Given the current emphasis on future unmanned systems that must rely on software for their operation, this is clearly a cause for concern.

In spite of this background, the F35's entry into service has been accompanied by a shift in media attention towards what the aircraft can achieve.[16] Systems in all three versions give both pilots and their network-enabled command and control partners unprecedented, three-dimensional, situational awareness of the battle space. Sensor-fusion was originally intended to help pilots penetrate sophisticated air defences without being detected but is now recognised as offering far more than that. An F-35 operating from a carrier using only its passive sensors can provide high-quality data to air and surface platforms, allowing any one of a number of surface or airborne platforms to engage airborne targets or fire missiles over-the-horizon against surface targets. The F-35 can, thus, be considered to have unlimited

magazine capability. When linked with an E-2D Hawkeye AEW aircraft through NIFC-CA, its greatest value might not even be as a fighter but as a sensor node transmitting data that is difficult to intercept. As such, a threat might be destroyed without even being aware that it has been detected or engaged. Over an amphibious task force the F-35B acting as a sensor node has the potential to contribute to fleet anti-air and anti-surface operations while directing gun and missile fire at targets obstructing the Marines' movement ashore. It is wrong to think of the F-35 simply as a new fighter. It really is a potential 'game-changer'.

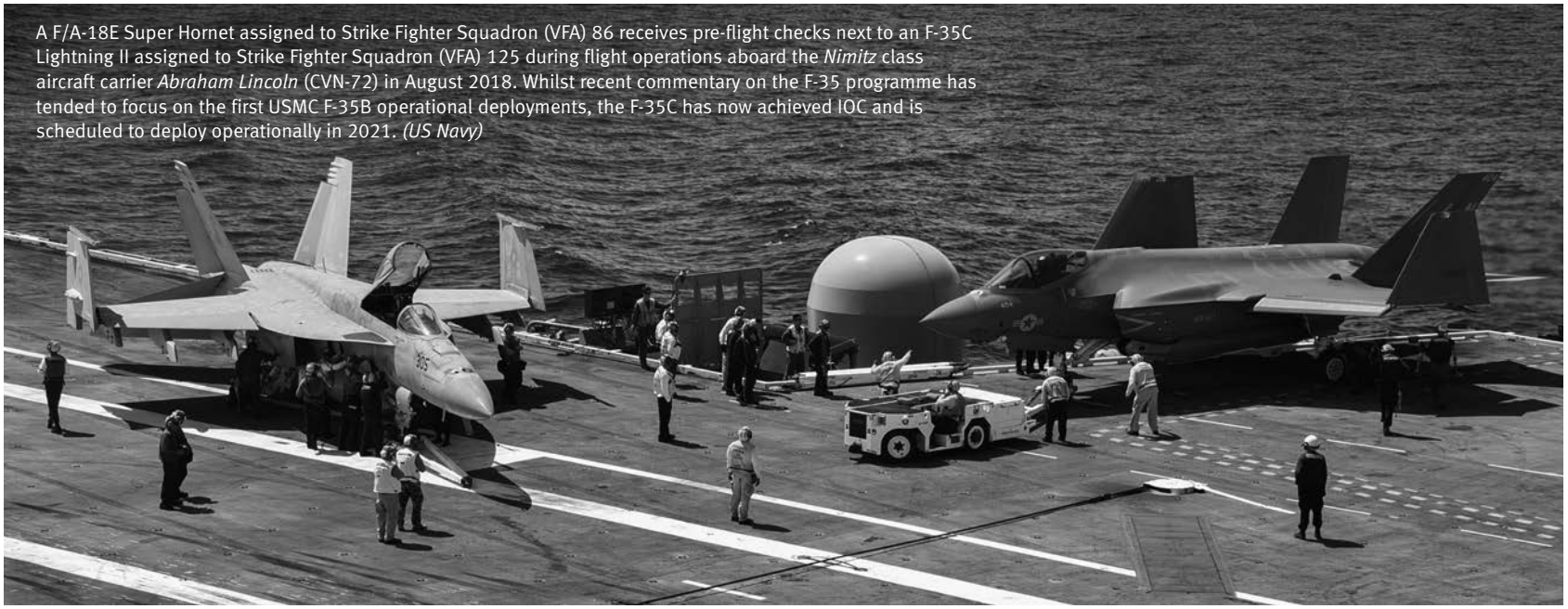
Essex (LHD-2) was the first amphibious carrier to deploy operationally from the United States with F-35Bs, embarking the USMC's VMFA-211, the 'Wake Island Avengers'.[17] She returned to her homeport of San Diego on 1 March 2019 after a deployment that generated lessons both on how to operate and sustain F-35Bs as part of a Marine Expeditionary Unit (MEU) but also how to use the strike fighter in support of blue water operations. Colonel Chandler Nelms USMC, commanding officer of the 13th MEU, and Lieutenant Commander David Mahoney USN, Amphibious Squadron 1's operations officer, briefed the Potomac Institute for Policy Studies about the deployment the following month. Mahoney said that it had changed the way amphibious carriers are employed. There was no nuclear-powered carrier in the Middle Eastern theatre for much of the time *Essex* operated there, meaning that duties normally performed by a carrier's Super Hornets were often flown by her F-35Bs. While emphasising that an amphibious carrier could never replace a carrier air wing, Lieutenant Commander Mahoney said that F-35Bs are now able to fill gaps left by the reduced number of deployed CVNs. Colonel Nelms added that 'We now have an aircraft capable of stealth operations which places fantastic sensors at the disposal of the MEU commander during ship-shore operations and also at the disposal of the Commodore as he seeks to maintain maritime and air superiority … so the difference[from the AV-8B] is vast'. However, with only six embarked Lightning IIs, the amphibious carrier could not sustain flying operations for 24 hours, nor in the aircraft numbers available from a fully-fledged strike carrier.[18]

A F-35B Lightning II attached to the 'Wake Island Avengers' of Marine Fighter Attack Squadron (VMFA) 211, 13th Marine Expeditionary Unit (MEU), launches from the flight deck of the *Wasp* class amphibious assault ship *Essex* (LHD-2) in September 2018 during the squadron's initial operational deployment with the aircraft. The F-35B carried out its first combat missions whilst *Essex* was deployed in the Middle East. *(US Navy)*

In late 2018 the US Navy stood up a Joint Strike Fighter Wing at Naval Air Station Lemoore in California tasked with overseeing F-35C training, manning and operational readiness. Lemoore has become the focal point of all F-35C training following the decision to deactivate its first fleet replacement F-35C squadron, the 'Grim Reapers' of VFA-101, which had been based at Eglin Air Force Base alongside US Air Force F-35A squadrons. This leaves VFA-125, the 'Rough Raiders', at Lemoore as the only F-35 training squadron. VFA-147, the 'Argonauts', achieved IOC with the F-35C on 28 February 2019 and the Joint Strike Fighter Wing must ensure that the squadron is prepared for its first deployment as part of a carrier air wing in 2021. It has ten aircraft at Block 3.F software standard. The second F-35C carrier deployment is scheduled to be conducted by a USMC unit; VMFA-314, the 'Black Knights'.

Software and its continuing development are central to the F-35 and will continue to be so. The current Block 3.F is the first operationally representative software package. Work is now progressing on Block 4, which is intended to add or fix fifty-three capabilities including nine that had been intended for 3.F but deferred. They range from major performance upgrades, through incorporation of new weapons (including national options for export customers), to problem resolution and minor performance enhancements. Every pilot input, selection, sensor or function is controlled through software. Accordingly, an aircraft's software block is critically important and any upgrade expensive. Block 4 implementation was originally estimated at US$3.9bn but – by 2018 – a Congressional hearing learnt that this had risen to over US$16bn. Of this US$10.8bn was for software development and testing and the balance for procurement of the upgrades, including the hardware needed to incorporate them. In 2019 it appears that even this may not be enough. Block 4 is a massive project in its own right, also known as Continuous Capability Development and Delivery (C2D2). It is to be delivered in phases designated 4.1 to 4.4 at intervals that could be as short as six months with concurrent hardware and software development, a philosophy that has already caused problems in the F-35's long evolution. Some software upgrades require new hardware that is, itself, still under development.

The F-35 Block 4 software is intended to allow frequent, responsive and quick changes to the



A F/A-18E Super Hornet assigned to Strike Fighter Squadron (VFA) 86 receives pre-flight checks next to an F-35C Lightning II assigned to Strike Fighter Squadron (VFA) 125 during flight operations aboard the *Nimitz* class aircraft carrier *Abraham Lincoln* (CVN-72) in August 2018. Whilst recent commentary on the F-35 programme has tended to focus on the first USMC F-35B operational deployments, the F-35C has now achieved IOC and is scheduled to deploy operationally in 2021. *(US Navy)*

aircraft's mission computer without the need for an extensive testing process, typically enabling the latest intelligence material to be loaded into the F-35's threat library. Phases 4.1 and 4.3 are primarily software; phases 4.2 and 4.4 include major new elements of hardware. Phase 4.1 is described as 'unlocking' the full capabilities inherent in the Lightning II's sensors and communications systems, especially the stealthy, tight-beam multi-function advanced datalink (MADL), which is to be made compatible with Link 16. It is also set to give the APG-81 AESA radar a wide-area synthetic aperture mode, allowing it to scan vast areas of terrain, track moving vehicles and create high-definition images for intelligence, navigation and weapons targeting. New United States weapons include the Small Diameter Bomb II, AIM-9X Block II 'lock-on after launch' missile and the B-61 nuclear bomb. Phase 4.2 is described as a 'technical refresh' involving new core processors, faster solid-state video memory and 4K high-resolution cockpit displays. The electro-optical system (EOTS), designed 15 years ago, is to be replaced by an enhanced system with a short-wave infrared sensor, high definition television, an infrared marker and superior image detection resolution. Block 4 aircraft may also include an upgraded engine with better fuel efficiency and greater electricity generation capacity to allow the installation of directed-energy weapons such as lasers.

Block 4 software is currently supposed to be available by 2023 but many regard this date as being at high risk of delay. The C2D2 approach also brings management challenges, as F-35 units will need to work with a specific software block ahead of deployments to ensure consistency. Upgrades would have to wait until after the deployment to ensure that all aircraft were at a common standard whilst embarked and both pilots and maintainers were proficient using the software they had. This, of course, could mean squadrons of F-35Bs and F-35Cs embarked in different ships could have aircraft with different software, with uncertain implications for both interoperability and tactics.

The F-35's ALIS automated logistics software continues to attract criticism for not functioning as intended. It is fundamental to every aspect of aircraft maintenance, flight planning and getting the right replacement parts to ships and airfields in time to return defective aircraft to flight as quickly as possible. However, ALIS software and data products are said to be complex and time-consuming to use. Maintainers frequently have to manually insert missing or incorrect electronic equipment logbook (EEL) data which is supposed to accompany spare parts so that they can be accepted and tracked by an ALIS standard operating unit at squadron level and installed on aircraft. Not surprisingly, users lack confidence in the system and Lockheed Martin is apparently investing US$180m to make improvements. ALIS was supposed to assist predictive maintenance, spare part procurement and the transmission of mission data to cut costs but does not yet perform as intended. Another uncertain area, given the growing threat of cyber warfare, is the system's potential vulnerability to cyber-attack by a sophisticated enemy.[19]

SEA CONTROL HELICOPTERS

The US Navy's swing towards widely distributed, unmanned systems has affected the MQ-8C Fire Scout unmanned aerial vehicle (UAV) programme, originally intended – *inter alia* – to help defend Littoral Combat Ships (LCS), against attacks by swarms of fast inshore craft. It is now perceived as a sensor node for targeting LCS weapons that are to have greater offensive lethality. Commander Edward Johnson, the USN Fire Scout requirements officer, told the WEST 2019 conference that the requirement has now shifted for it to become 'a more sensor laden targeting platform'. He told the conference that the MQ-8C must have 'the right sensors, a good multi-function radar, some kind of passive targeting capability and the right networks to push that information to the right people at the right time'. The comparison with growing F-35 experience is obvious and he felt that the MQ-8 'C' model, especially, '… would be able to greatly extend the range of the

An Indian Navy Sea King helicopter from the destroyer *Rajput* pictured on the flight deck of the US Navy amphibious transport dock *Anchorage* (LPD-23) on Boxing Day 2018. The helicopter was the first Indian machine to land on a US Navy warship under a Helicopter Operations from Ships other Than Aircraft Carriers (HOSTAC) agreement signed in October 2017. *(US Navy)*

Two MQ-4C Triton unmanned maritime patrol aircraft – reportedly serial numbers 168460 and 168461 – of Unmanned Patrol Squadron 19 (VUP-19) pictured at Naval Base Ventura County on 31 May 2018. The squadron's insignia can be seen in the background. One of these aircraft was subject to a crash landing in September 2018 that caused over US$2m of damage and delayed the type's first forward deployment. *(Northrop Grumman)*

sensors of an LCS to find and target threats'. Northrop Grumman is evaluating the potential introduction of the Leonardo Osprey 30 AESA radar, and Link 16 into the UAV. Thus modified, an airborne MQ-8C could generate targeting information for an LCS out to about 300 nautical miles and several could be embarked to give continuous cover. A comprehensive MQ-8C initial operational test and evaluation phase was completed in June 2018 on *Coronado* (LCS-4) with an aircraft from VX-1 squadron.[20]

The Royal Australian Navy is also developing its UAV operating capabilities. On 26 October 2018 it commissioned 822X NAS at Royal Australian Navy Air Station Nowra, tasked with operating unmanned aerial systems in the maritime domain. The Chief of Navy, Vice Admiral Michael Noonan, described the event as 'a significant moment for the Navy and the Fleet Air Arm and noted that the 'X' indicates the developmental nature of the unit. It operates Insitu ScanEagles and Schiebel S-100 Camcopters, both capable of being embarked in a variety of warship types.

In late December 2018 an Indian Navy Sea King helicopter landed on the flight deck of the US Navy's *Anchorage* (LPD-23), marking the first cross-decking aircraft operations between the two navies under an agreement first signed in 2017 and an important point in their relationship. The ship had just visited Visakhapatnam and was carrying out exercises with India's *Rajput*, a guided-missile destroyer. The two navies had agreed a programme for the operation of helicopters from ships other than aircraft carriers in 2017 and the cross deck operations are seen as strengthening maritime security co-operation in the Indian Ocean. India also looks set to be the latest customer for the MH-60R version of the Seahawk helicopter following receipt of US approval that should allow conclusion of a c. US$2.4bn deal for 24 of the rotorcraft in April 2019.

MARITIME PATROL AIRCRAFT

Boeing marked a major milestone on 12 October 2018 with the delivery of its 100th P-8 maritime patrol aircraft, a P-8A Poseidon destined for US Navy service. As of January 2019, there were aircraft on the production line for Australia, India, Norway and the United Kingdom as well as the US Navy, with eighteen aircraft per year being completed. New Zealand and South Korea have also announced

orders for the P-8 – for four and six aircraft respectively – over the last year.

The P-8 is to be known as the Poseidon MRA 1 in British service and the first of nine aircraft is to be delivered in late 2019 with IOC following in 2020. They are expected to operate, initially, over the North Atlantic and Arctic as part of a trilateral P-8A partnership with the US Navy and Norway. The United Kingdom's subsequent purchase of the E-7 Wedgetail ASaC aircraft which, like the P-8, uses an airframe based on the commercial Boeing 737 may have a significant impact on future joint maritime operations, although it is not, strictly, an MPA.

The P-8A's unmanned partner in the MPA role is the unmanned MQ-4C Triton. Its first operational unit is VUP-19 Squadron, the first in the US Navy to consist solely of unmanned aircraft. Its operations were suspended in September 2018 while the crash landing of an MQ-4C in California was investigated, impacting the timing of a planned forward deployment to Guam. VUP-19 forms part of Patrol and Reconnaissance Wing 11 and is co-located at Naval Air Station Jacksonville, Florida with P-8A Poseidons, although operations are also carried out of Naval Base Ventura County. The MQ-4C has been ordered by Australia and, once it is established in service, may be attractive to other P-8 operators.

Notes

1. H.R. 2810/P.L. 115-91 of December 12, 2017.

2. Further detail on the block buy is contained in Ronald O' Rourke's periodically updated *Navy Ford (CVN-78) Class Aircraft Carrier Program: Background and Issues for Congress*: *RS20643* (Washington DC: Congressional Research Service), available on the Federation of American Scientist's website at: https://fas.org/sgp/crs/weapons/RS20643.pdf. The US Navy has undertaken two-ship carrier procurements before but not since the end of the Cold War.

3. Pat Shanahan assumed the role of Acting Secretary of Defense on 1 January 2019 following the resignation of the previous incumbent, James Mattis, over disagreements with President Trump. In May 2019 Trump stated he would nominate Shanahan to take over the role permanently but he resigned for personal reasons on 18 June 2019.

4. There should usually be at least two CVNs continuously on station, typically one in the Pacific and one in the Middle East, with three more at or close to their base ports available for surge operations. The remainder will be undergoing maintenance or otherwise at reduced readiness. The carrier strike groups' weekly location can be seen in Strafor's weekly naval update map at: worldview.stratfor.com/topic/tracking-us-naval-power. This also shows the location of deployed amphibious ready groups. During 2018 *Truman* operated in the Arctic Circle off Norway for NATO exercise Trident Juncture, becoming the first US Navy carrier to enter the Norwegian Sea for nearly 30 years. The exercise was the largest in decades, a measure of the concern that has followed the growing threat from Russia in the region.

5. The Trump administration's volte-face on *Truman* was widely reported, often with the accompaniment of some irony. For example see Joe Gould and David B Larter, 'Trump reverses his own aircraft carrier policy, takes a victory lap' posted to the *Defense News* website on 1 May 2019 at: https://www.defensenews.com/congress/2019/05/01/trump-reverses-his-own-aircraft-carrier-policy-takes-a-victory-lap/

6. Bryan Clark, Adam Lemon, Peter Haynes, Kyle Libby, Gillian Evans, *Regaining the High Ground at Sea: Transforming the U.S. Navy*'s *Carrier Air Wing for Great Power Competition* (Washington DC: CSBA, 2019), available at: https://csbaonline.org/research/publications/regaining-the-high-ground-at-sea-transforming-the-u.s.-navys-carrier-air-wi

7. See Megan Eckstein's 'SECNAV to Trump: Ford Carrier Weapons Elevators Will be Fixed by Summer, or "Fire Me"' posted to the *USNI News* site on 8 January 2019 at: https://news.usni.org/2019/01/08/secnav-to-trump-aircraft-carrier-weapons-elevators-to-be-fixed-by-summer-or-fire-me

8. See Ben Werner, 'Nimitz and Ford Carriers Need Upgrades to Deploy With F-35Cs' posted to the *USNI News* site on 7 June 2019 at: https://news.usni.org/2019/06/ 06/nimitz-and-ford-carriers-need-upgrades-to-deploy-with-f-35cs

9. See another of Ben Werner's articles, 'Navy Fighter Readiness Nearing 80 Percent Mission Capable Target' posted to the *USNI News* site on 5 April 2019 at: https://news.usni.org/2019/04/05/42436

10. The deal encompasses the last six Super Hornets authorised in FY2018 plus authorised or planned procurement from FY2019 to FY2021.

11. According to the Blue Angels fact sheet, '... each has to be capable of being returned to combat duty aboard an aircraft carrier within 72 hours'.

12. Captain Cooke-Priest assumed command of *Queen Elizabeth* from Captain Jerry Kyd whilst the ship was visiting New York between DT-1 and DT-2. He was subsequently prematurely transferred to other duties in controversial circumstances in May 2019.

13. See Pierre Tran's 'What will launch from France's future aircraft carrier? The government and Navy are teaming up to find out' posted to the *Defense News* website on 26 September 2018 at: https://www.defensenews.com/digital-show-dailies/euronaval/2018/09/26/what-will-launch-from-frances-future-aircraft-carrier-the-procurement-office-and-navy-are-teaming-up-to-find-out/

14. See 'Tracking the Type 002 – China's third aircraft carrier' posted to the *ChinaPower* website on 6 May 2019 at: https://chinapower.csis.org/china-carrier-type-002/

15. The significance of the proposed MUX was highlighted by Megan Eckstein in 'Marines Won't Need a Carrier for High-End Fight With MUX Unmanned System' posted to the *USNI News* site on 6 June 2018 at: https://news.usni.org/2018/06/06/marines-wont-need-carrier-high-end-fight-mux-unmanned-system

16. This is by no means a universal trend. For example, the *Defense News* website ran a series of articles under the banner 'The Hidden Troubles Of The F-35' in June 2019. See: https://www.defensenews.com/smr/hidden-troubles-f35/

17. The forward-deployed *Wasp*, based in Japan, became the first amphibious assault ship to deploy the F-35B operationally in March 2018 when she embarked VMFA-121, the 'Green Knights'.

18. The briefing was again covered by *USNI News'* Megan Eckstein in 'F-35B Allowed *Essex* ARG to Flex New Blue-Water Capabilities in Absence of Carrier Nearby' posted on 16 April 2019 at: https://news.usni.org/2019/04/16/f-35b-allowed-essex-arg-to-flex-new-blue-water-capabilities-in-absence-of-carrier-nearby

19. The ALIS problems were highlighted by the often-critical Office of the Director, Operational Test & Evaluation (DOT&E) in the F-35 related section of the *FY2018 DOT&E Annual Report* (Washington DC: DOT&E, 2019) at pp.23–36.

20. See further Mike Rees, 'US Navy Fire Scout UAS to be Redesigned' posted to the *Unmanned Systems Technology* website on 27 February 2019 at: https://www.unmannedsystemstechnology.com/2019/02/us-navy-fire-scout-uas-to-be-redesigned/

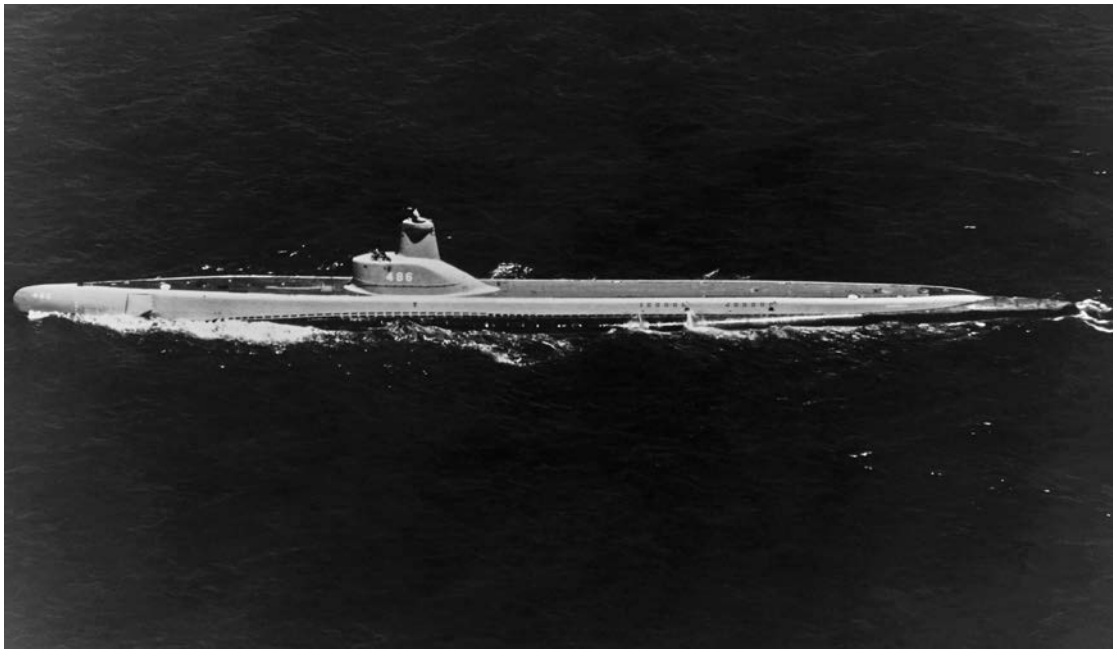
4.2 TECHNOLOGICAL REVIEW

FUTURE SUBMARINE TECHNOLOGY

Some Considerations

Author:
Norman Friedman

Submarines are both increasingly important and increasingly expensive. The question for all navies which operate them – or want to do so – is where submarine technology is going and how to insure against the risk of rapid obsolescence. If the latter seems too overblown a possibility, readers may want to remember how most of the world's submarines were suddenly made obsolescent after the Second World War with the appearance, first, of fast battery submarines (inspired by the wartime German Type XXI) and, then, with nuclear submarines. Navies had to choose between expensive rebuilding programmes – like the US Navy's 'Guppy' and the British 'Super T' – or massive new construction along the lines of the Soviet 'Whiskey' (Project 613). Are we approaching a similar crisis today?[1]



The acquisition of technology from captured German Type XXI U-boats at the end of the Second World War resulted in the extensive reconstruction of many existing American and British submarines to avoid obsolescence. The US programme was known as the Greater Underwater Propulsion Power Program (GUPPY) – this picture shows *Pomodon* (SS-486), one of two prototype modernised boats, in July 1947. Submarine-operating navies today have to guard against technological developments causing similar block obsolescence. *(US Naval History & Heritage Command NH 90890)*

POWER PLANTS

It seems unlikely that some new kind of nuclear power or its equivalent is coming. In the 1960s there were some in the United States, and doubtless also in the Soviet Union, who imagined that a new generation of lightweight, gas-cooled reactors was in the offing. In such power plants, the reactor core would heat helium, which would then drive a gas turbine.[2] It turned out that these reactors were impractical. Instead, the main developments in reactor design were long-life, ultimately 'single shot' cores and, in at least some cases, natural circulation. The latter did away with noisy pumps, at least at low speed. For the future, the main possibility is presumably some means of directly converting the heat of the reactor into electricity to drive the submarine. There is no indication that any such development is imminent and it may never be practicable.

The main recent developments have been in the area of improved silencing. Examples include the use of pump-jets to eliminate blade rate and substitution

Absent the development of new reactor technology, improvements to current nuclear-powered submarines have been focused on the area of stealth, particularly silence. This model of the US Navy *Virginia* class attack submarine *Delaware* (SSN-791) shows the quiet pump-jet propulsor derived from British Royal Navy practice. *(Huntington Ingalls Industries)*

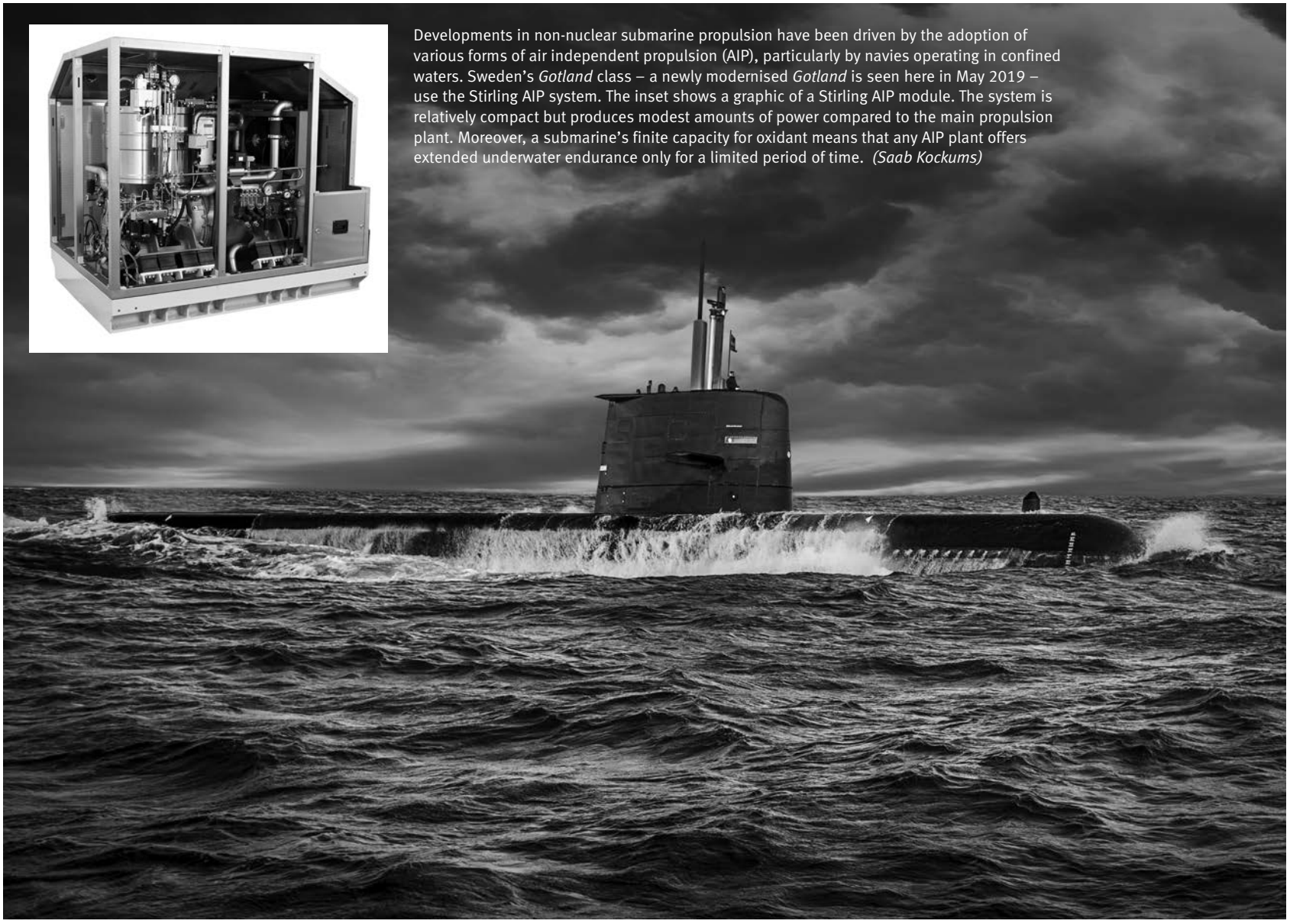
of turbo-electric for geared-turbine propulsion. Neither is very new. The Royal Navy introduced pump-jets several decades ago and they feature in the current US Navy *Virginia* (SSN-774) class. The US Navy tried turbo-electric drive in the 1970s, with unhappy results. However, it is used by the French Navy and has been resurrected in the United States for the projected *Columbia* (SSBN-826) class strategic submarines. Generally it requires more volume and weight than geared turbines, but it is inherently quieter. There is also continued work on anechoic coatings to defeat active sonars.

The situation for non-nuclear submarines may be more complex. Until very recently, the important development has been air-independent propulsion (AIP), the main technologies being fuel cells and Stirling engines. In each case, the submarine uses a secondary power plant to drive her at low speed for a sustained period. This avoids noisy and potentially risky snorkelling. Endurance from the AIP plant – typically a few weeks – depends on how much oxidant the submarine carries, which in turn depends on submarine volume. The tanks may be outside the pressure hull, as in the case of the German Type 212A.[3] Importantly, they generally cannot be replenished while the submarine is underway. German designers have claimed that an all-AIP power plant is in sight. Since current plants have very limited output, the question is whether it is worthwhile to gain long non-snorkelling endurance at the price of much lower maximum speed.[4]

In theory, AIP is valuable because it makes a submarine far less detectable. However, most – perhaps all – of the world's submarines operate in areas in which surveillance is hardly intensive or constant. The German and the Swedish navies worked hard on AIP because they expected to operate in the Baltic, which arguably did subject their submarines to intensive surveillance.[5] Whilst an account of the passage of an AIP submarine from the Baltic to the Mediterranean stressed that the submarine had not been detected en route, it has never been clear that NATO has any sort of fixed submarine detection system in the Mediterranean. It is possible that ships with long-range surveillance arrays were deployed specially to try to detect the submarine. However, equivalents would not be deployed in most of the world's oceans.

The invisibility brought by AIP of any type also has a real cost, not only in terms of dollars but also in complexity. Even without AIP, a submarine is an extremely sophisticated machine with only a small crew to deal with possible breakdowns. Given limited internal volume, there may be a trade-off between the number who can crew the combat system and those available to maintain and operate the submarine's power plant. The finite capacity for oxidant also means that any AIP plant offers invisi-

A graphic of the lead ship of the US Navy's new *Columbia* (SSBN-826) class of strategic missile submarines. In a departure from recent US Navy practice, she will employ turbo-electric drive to aid silencing. *(US Navy)*



Developments in non-nuclear submarine propulsion have been driven by the adoption of various forms of air independent propulsion (AIP), particularly by navies operating in confined waters. Sweden's *Gotland* class – a newly modernised *Gotland* is seen here in May 2019 – use the Stirling AIP system. The inset shows a graphic of a Stirling AIP module. The system is relatively compact but produces modest amounts of power compared to the main propulsion plant. Moreover, a submarine's finite capacity for oxidant means that any AIP plant offers extended underwater endurance only for a limited period of time. *(Saab Kockums)*

bility for a limited period of time, not for a submarine's entire patrol. In any case, submerged endurance is limited by the crew's need for oxygen. Unlike a nuclear submarine, a conventional boat lacks the power to break down seawater to produce fresh oxygen and the usual oxygen-generating candles have limited value. An AIP submarine may be able to use some of the stored oxidant to replenish its atmosphere, but at the expense of AIP endurance. Otherwise, the submarine must connect to the atmosphere. Although that connection will not be particularly noisy, it will produce a detectable radar target.

The longer the intended operating range of the submarine, the more she must rely on conventional power for transits to a patrol area; otherwise she spends all of her endurance en route. The question, then, is whether there is any submerged plant which can be replenished at sea. Clearly this is already the case with batteries, which are replenished by the submarine's own diesels. The problem is that – typically – they suffice for only about 24 or 48 hours submerged as compared to a week or more with AIP. However, it is possible that the developing technology of lithium batteries may offer several days' endurance – which can, of course, be replenished whenever the submarine snorkels. Japan has already adopted this technology for their latest submarines.[6] It would appear, moreover, that commercial pressure to develop lithium batteries for electric cars will accelerate improvement. Against that, high-capacity lithium batteries have sometimes been considered a fire hazard in the recent past.

SUBMARINE ROLES

The other question is how submarine roles will evolve due to a combination of changed conditions and new technology. In the past, most submarines, particularly diesel-electric ones, were optimised for open-ocean attack.[7] In these boats, the combat system was designed to create a usable tactical picture on the basis of the various sonar arrays on board the submarine. Once the command designated a target, the combat system could track it and engage it. For many navies, this will remain the submarine role well into the future. For example, countries around the disputed South China Sea have bought submarines in recent years largely to deter China from opposing them with major warships.

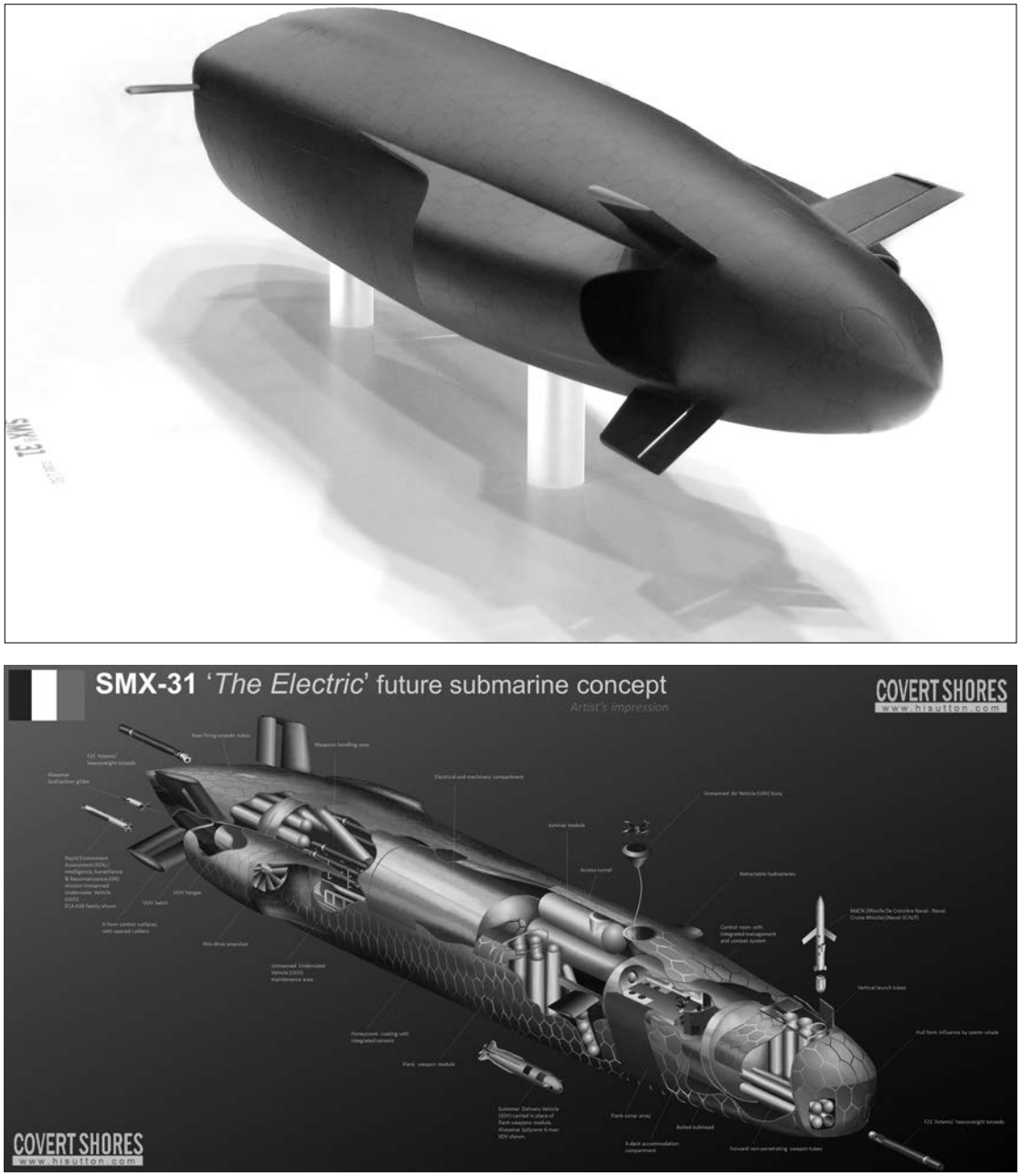
However, the Chinese are increasingly deploying quasi-naval forces – even nominally civilian ones – in this area. At the very least, they are greatly complicating the tactical picture a submarine must form when it operates in areas that China seeks to control. It is no longer enough, as in the past, for a submarine commander to make a quick scan using his periscope to resolve the identities of nearby ships.[8] To some extent this problem is being simplified by the advent of electro-optical periscopes, which can quickly capture a scene for analysis. On the other hand, combining the electro-optical picture with sonar data probably requires more system operators – and a larger combat system space.

Electro-optics offer considerably more, at least in theory. A conventional optical periscope requires a clear optical path between its window, at the top, and its eyepiece in the control room. That places the control room directly below the mast and, unless the mast can telescope down, the submarine needs sufficient hull depth to accommodate the mast. Typically the mast must be long enough that a submarine operating at periscope depth is not much affected by usual surface sea conditions.

An electro-optical periscope needs only a wire to send its data down into the submarine. It need not

The JMSDF submarine *Soryu* (SS-501) pictured mooring alongside the submarine tender *Frank Cable* (AS-40) at Guam in June 2018. Original *Soryu* class submarines are equipped with Stirling AIP but some later members of the class will be fitted with lithium-ion batteries as an alternative means of extending underwater endurance. *(US Navy)*

Sailors and Military Sealift Command personnel assigned to the submarine tender *Emory S. Land* (AS-39) hoist a submarine periscope from the pier to be loaded onto the ship. A conventional optical periscope requires a clear optical path between its window, at the top, and its eyepiece in the control room below, meaning the submarine must have sufficient hull depth to accommodate the mast. This problem is considerably simplified by the arrival of the new generation of electro-optical periscopes. *(US Navy)*



A model and cutaway drawing of the Naval Group's SMX 31 concept submarine, which was presented at the Euronaval 2018 trade show. The concept provides a good indication of many of the technologies that might be adopted in future submarines and is notable for lack of a fin or sail. A detailed examination of the design suggests it might not be a practical proposition as currently configured. *(Norman Friedman/H I Sutton, Covert Shores)*

even be mounted rigidly on the submarine; in theory, it can be placed in a body floating some distance from the host vessel. The mere act of disconnecting the viewing device from the hull of the submarine means that spotting the device does not necessarily reveal the submarine's position. This is aside from the radical change in submarine operating procedure resulting from the fact that the electro-optical device captures an image which can be stored for further use. This image can, for example, be correlated with what the submarine's sonars show.

At the Euronaval 2018 trade show, France's Naval Group displayed a model of a concept submarine designated SMX 31. It exploited both electro-optics and lithium batteries and seemed particularly adapted to future littoral missions.[9] It had an all-electric propulsion system employing only lithium batteries, which would be charged up at its base.[10] Endurance at low speed would be 30 to 45 days whilst maximum speed would be 20 knots. Without any diesel, the submarine did not need a snorkel. Since it employed an electro-optic sensor in a floating body, it also did not need a fin (US Navy sail) to accommodate a periscope mast. Eliminating the usual fin had considerable advantages. It allowed for a better hydrodynamic shape, and it solved the problem of snap-roll.[11] The crew could be reduced to fifteen – and limited to vital functions – by aggressive use of artificial intelligence. Naval Group did not, however, indicate any solution to the one submarine function which has caused navies to retain fins, namely the need for a bridge to conduct inshore navigation. A cross section suggested that the submarine would be too full of equipment to accommodate a retractable bridge. As shown, the model also did not explain how the submarine was to solve the habitability problem: where was the oxygen for 30 days or more? It might use a telescoping snorkel but, in this case, its fin-less design would need some special means of maintaining depth near the surface.

LIMITS AND MARGINS

An important point to keep in mind is that a submarine is far more limited in margin than a surface ship. Adding weight to a surface ship pushes her somewhat deeper in the water but may not have any great consequences. Nor is added volume usually a great problem, as it is possible to add or expand a deckhouse. A submarine, however, must maintain a perfect balance between her volume and her weight. Typically a submarine is completed with lead weights on her axis (plus, usually, some lead to improve stability). The lead represents her growth margin; every pound added to, say, her combat system is balanced by removing a pound of lead. To some extent a submarine can add more weight and volume externally if the external items do not need

to come inside the pressure hull. To some extent, too, the submarine can gain internal volume by opening her up and extending her hull.[12] However, any such modification can be expensive, not only in cash terms but also in terms of performance.

The most obvious margin is in electronic capability. At the end of the Cold War, the US Navy realised that it could not afford to buy more and more massive sonar arrays to overcome Soviet silencing. It found that improved signal processing was a much more economical path. Moreover, computer power kept improving without demanding more space or even more electric power. In the 1990s the navy instituted a rolling program of hardware and software improvement known as A-RCI (Acoustic Rapid COTS Insertion). It is not clear to what extent other navies followed suit. US Navy submarines were well equipped to exploit added computer power, not least because they had space for elaborate combat systems with many operators. These systems, moreover, were not tightly integrated. Adding computer power to an existing, tightly-designed combat system may be considerably more difficult.

A-RCI was one application of digital electronics. However, submarines offer examples of others. For example, the *Virginia* (SSN-774) class has what amounts to 'swim by wire' control. In the past, moving a control actuated hydraulics which in turn moved a plane or rudder. In the new system, the movement of a control is translated into a digital signal which causes an electric motor to move the rudder or plane. This directly provides a considerable saving in weight and also has more far-reaching implications. As in a fly-by-wire aircraft, the computer interposed between the controls and the control surfaces can move the latter in a coordinated way, for example to resist snap-roll or to take evasive action in conjunction with the launch of decoys. This sort of control possibly requires more electric power, but that is no problem for a nuclear submarine. As is the case for new surface ships, the combination of digital signals and electric drive offers many other opportunities, such as feedback to reduce self-noise which a submarine's systems detect and characterise.

For that matter, there have been proposals dating back many years to provide a submarine's command with something more like a three-dimensional view of the surrounding ocean. That might provide the command with a better idea of how to pass through the ocean in the least detectable way. Current

The US Navy *Los Angeles* class nuclear-powered attack submarine *Santa Fe* (SSN-763) pictured on exercises with four smaller Royal Australian Navy *Collins* class diesel-electric submarines off Western Australian in February 2019. *Santa Fe* was one of many US Navy submarines that benefitted from the A-RCI improvements to her computing power to enhance sonar performance without significant changes to her actual arrays. The *Collins* class – which use the same US-supplied combat system now fitted to the remaining *Los Angeles* class boats – are also benefitting from sonar improvements but this will extend to replacement of their physical arrays. *(Royal Australian Navy)*

computing power seems to offer that possibility in a way impossible when the idea was first raised a few decades ago.

COST AND NUMBERS

Submarines are becoming more and more expensive, which means that navies will have to settle for fewer of them. For example, the US Navy now operates about half as many nuclear attack submarines as it did at its Cold War peak. The reduction in numbers will not, of course, be matched by any reduction in areas that submarines must or should cover. One way to maintain sufficient coverage with fewer submarines is to increase submarine endurance. There is a vast difference between a submarine which can remain at sea for 30 days and one which can remain deployed for 60 or even 90 days. The longer the required endurance, the more attractive nuclear power becomes.

It seems arguable that submarines' footprints will have to grow to compensate for the loss of numbers. From a weapons point of view, this would seem to imply the deployment of weapons with greater ranges. This would, in turn, favour submerged-launch missiles over torpedoes, although only if the submarine's surveillance range increases to match the greater range of the missiles.

This may or may not be feasible. For example, the US Navy and the Soviet Union both operated submarine-launched anti-submarine missiles but, at least in the American case, the weapon was abandoned as ineffective.[13] In the case of anti-ship weapons however, submarine-launched unmanned air vehicles may make long-range shots a practicable proposition. A submarine which could engage targets over a wider area would presumably need more weapons, which in turn would place demands on the boat's volume. Alternatively, some weapons could be carried externally, which would place fewer demands on the submarine. It is also possible that weapons can be miniaturised. In the past, there have been repeated claims that it will soon be possible to produce much more energetic explosives, which

Reductions in submarine numbers mean that the remaining fleet has to cover more ground. This would seem to imply the deployment of weapons with greater ranges, favouring missiles over torpedoes. This picture shows the submarine *Olympia* (SSN-717) loading a Harpoon anti-surface missile in July 2018 in preparation for the RIMPAC exercises. This was the first time a US Navy submarine had fired Sub-Harpoon for a number of years. *(US Navy)*

could be carried by much smaller weapons. It is not clear whether such claims are likely to be realised.

The other kind of footprint is intelligence-gathering. Submarines are often used for covert reconnaissance, including collecting signals intelligence. It is sometimes said that satellites and aircraft can easily collect signals but that the target knows when they will be watching and can shut down accordingly. A covert submarine is a very different matter. The obvious question is whether the intelligence-gathering footprint can – or should – be enlarged by using unmanned vehicles. At the very least, they would allow a large submarine to collect what is needed from further offshore. Preferably, however, a submarine would operate multiple vehicles. Autonomous undersea vehicles (AUVs) already exist and can be launched by submarines. However, the problem of retrieving them seems not to have been solved. Unless they can be retrieved, there must be a question as to how reliably data from an unmanned vehicle can be fed back into the parent submarine, presumably using some form of acoustic modem.

Unmanned vehicles carry real costs for a submarine. They require power; if they can be retrieved that will mean either refuelling them or recharging their batteries. They take up space. Perhaps more importantly, if they are used to collect information, that information must generally be processed on board a submarine before something can be sent back home for further use. Alternatively, if the unmanned underwater vehicles (UUVs) are expendable, they must transmit the information they have acquired in some way. All of this imposes a load on the energy produced by the submarine and probably requires more submarine volume. The consequence is a larger and more expensive submarine.

The other AUV question is whether such vehicles can extend a submarine's lethal footprint. Some years ago, once medium-range underwater acoustic communication had been demonstrated, the US Navy's underwater systems centre (NUSC) at New London proposed an armed UUV it called Manta (after the fish). A submarine could launch several Mantas to, for example, cover several entrances to a

Deploying unmanned vehicles carry real costs for a submarine, including the need for space. For example, *Jimmy Carter* (SSN-23) – the third *Seawolf* class submarine – was extended by around 100ft during build to incorporate a multi-mission platform capable of deploying both remotely-operated vehicles and Special Forces. This picture shows General Dynamics Electric Boat moving the submarine outdoors for the first time in June 2004. *(US Navy)*

Just as submarines will require weapons with longer ranges, so they will need the potential to deploy systems allowing surveillance over greater distances. This picture shows a Bluefin 12D unmanned underwater vehicle being prepared for use onboard a surface vessel – operations, particularly recovery, of such systems from a submarine pose more difficulties. *(US Navy)*

port. They would transmit back what they found and those on board the submarine could decide whether to fire torpedoes remotely. Although a model Manta was built, it did not approximate to the device desired because it lacked sufficient energy to attain the necessary performance. NUSC produced a video showing what Manta could achieve; it was set in 2050 when the necessary energy was likely to be available.

Submarines are valuable because they are invisible. Their roles have changed considerably over time, because different uses for that invisibility have been found. It seems unlikely that invisibility will be lost in the next few decades. Indeed, increased commercial use of the sea, particularly on the continental shelves, will probably make the seas considerably noisier and submarine detection more, rather than less, difficult. It does seem, however, that to remain viable submarines are likely to grow larger. This will make nuclear power more and more attractive, assuming it is affordable. Thus far the path to nuclear power seems to have been quite difficult. An important future question is whether it is likely to become any easier given nuclear reactor technology is so widely diffused.[14]

The Royal Navy's lead *Astute* class nuclear-powered attack submarine pictured departing the Clyde in October 2018. Submarines remain valuable weapons because of their invisibility, with pressures on size likely to favour nuclear propulsion to the extent it is affordable. *(Crown Copyright 2018)*

Notes

1. All views expressed are the author's and should not necessarily be associated with the US Navy or with any other entity with which he has worked.

2. The other alternative was a liquid-metal coolant. This offered very high power density but incurred very serious operational and safety problems. The US Navy trialled the technology with the sodium-cooled S2G reactor initially installed in the 1950s-era *Seawolf* (SSN-575). Soviet use encompassed a single Project 645 'November' class boat commissioned in 1963 and then the 1970s era Project 705 'Alfa' class. There were several accidents in Soviet service, with the risk of the coolant solidifying and freezing up the reactor a particular problem. It seems very unlikely that this type of reactor will ever be revived.

3. AIP cannot offer the sort of sustained high performance which nuclear power buys as no such plant burns fuel with sufficient energy content. Storage batteries have even less energy content, which is why they do not offer anything like the endurance claimed for AIP.

4. The German Type 212A uses oxygen and hydrogen in its fuel cells. It is credited with an AIP endurance of 3,000 nautical miles at 4 knots: the equivalent of 750 hours or over 30 days. Battery endurance is 420 nautical miles at 8 knots or about 50 hours. Maximum underwater speed – on the battery – is 20 knots, probably for around one hour.

5. Since the end of the Cold War, reliable accounts of Soviet-era acoustic systems – written by Russians from the design bureaus – have become available. It is clear that the Soviet Union never fielded a passive surveillance system comparable to the Western SOSUS. At the end of the Cold War they began to field an active system. AIP would offer no immunity against such technology. It is not clear what underwater surveillance the Chinese are trying to set up in the South China Sea; some accounts of the 'underwater Great Wall' suggest that it employs an acoustic fence which would detect the unavoidable flow noise of a submarine passing overhead. Again, AIP would be irrelevant against such a system.

6. Current members of the Japan Maritime Self Defence Force's *Soryu* class employ conventional lead-acid batteries and Stirling AIP engines. However, the last two members of the class will have lithium batteries instead. Reports suggest battery endurance at low speed will be eight days whilst endurance at maximum speed will be tripled.

7. There were obvious exceptions. In 1957 the US Navy, which was already operating submarines focused on anti-submarine warfare, decided that all future submarines would be optimised for that role. The result was the construction of the *Thresher* (SSN-593) and *Sturgeon* (SSN-637) classes with their dramatic advances in silencing due to rafting and their big bow sonar. The British Royal Navy similarly optimised its later nuclear attack submarines for anti-submarine operations and at least one account of the *Upholder* class diesel-electric submarine class describes its role primarily as a means of maintaining a passive sonar barrier in the Greenland-Iceland-UK (GIUK) gap.

8. It can be argued, moreover, that the rise of long-range sonars – including towed arrays – and shipboard helicopters, means that no quick local scan tells the command enough. That is apart from the reality that a submarine's own acoustic sensors are operating at longer ranges than in the past and greatly increasing the amount of information the submarine command team must sift and interpret.

9. SMX 31 is one of a series of concept submarines displayed by Naval Group at naval trade shows. It is, perhaps, the most exotic of the series to date, other previous innovations including a fuel cell which could maintain a submarine on patrol for a month at a time. SMX 31's characteristics include a submerged displacement of c.3,400 tons, a length of 70m, a beam of 13.8m and a hull depth of 9.7m. The hull form is said to be based on the shape of a whale, fat at the bow and slim aft. There are retractable bow planes and an X-stern. Instead of a propeller or pump-jet, the design incorporates a pair of side nacelles carrying rim-driven propulsors. There are various torpedo and vertical launch tubes, with claimed weapon capacity being up to as many as forty-six full-sized torpedoes or equivalents. SMX 31 also incorporates a special diver trunk – in the past Naval Group has emphasised the use of submarines to support Special Forces divers. Test depth was given as more than 250 metres.

10. The earliest French submarines were all-electric, with their batteries charged at the pier. This type of propulsion was abandoned because of a consequent lack of range.

11. As a submarine turns, water flowing over the fin exerts a sideways force which causes the submarine to roll. The fin can also blank a submarine's control surfaces. A large fin can add to the noise generated by a submarine, as the blades of its propeller bite into the fin's wake.

12. As in, for example, the U S Navy's radar picket conversions of the 1940s and 1950s and the British 'Super T' conversion of 'T' class submarines for high underwater speed in the latter decade. More recent examples include the drastic modification of *Jimmy Carter* (SSN-23) as a special operations submarine whilst under construction and the proposed lengthened version of the *Virginia* class by incorporation of the Virginia Payload Module.

13. The US Navy weapon was the SUBROC missile, with a range of about 35 nautical miles – one convergence zone. It had a nuclear warhead, which was necessary to make up for the uncertainty in target location at so great a distance. A proposed alternative version using a homing torpedo was abandoned because the torpedo was unlikely to find its target. Ultimately SUBROC itself was abandoned because the US Navy did not want to rely on nuclear warheads, authority for whose release might not have been given. The Soviets had a similar weapon, with both nuclear and non-nuclear variants, which seems to have survived. SUBROC itself was conceived in combination with the long-range BQQ-2 sonar and a digital fire-control system. The US Navy also had a submerged-launch version of the Harpoon anti-ship missile, which was abandoned, but may now be revived. Reportedly submarine commanders preferred torpedoes, which they considered more effective and which were used at ranges at which the commanders could more easily identify their targets. They also disliked the rather visible column of smoke and water created when a Harpoon was launched. Submerged-launch Tomahawk was acceptable because its launching signature was likely to be so far from any hostile force. The anti-ship version was unpopular – and was abandoned – because submarines could not be given enough information to have reasonable confidence that they would not hit non-targets.

14. There seems to be no question that the Soviets developed their submarine reactors independently of the United States. The first British Royal Navy submarine, *Dreadnought*, used a US Navy Westinghouse S5W reactor and, although subsequent reactors were claimed to be of purely British design, the latest PWR3 reactor is acknowledged to have American design influences. It was also widely claimed that the first French reactors employed stolen US Navy technology. However, French attack submarine reactors and later SSBN and carrier reactors are very different from US and British Royal Navy ones as they are adapted to use much lower-enriched uranium, which has to be replaced more frequently. Elsewhere, China probably began with some Soviet technology, obtained before assistance ended with the Sino-Soviet split, and India continues to benefit from Russian assistance. At present the only other announced nuclear submarine programme is Brazil's. It has moved very slowly and has yet to produce a viable submarine-scale reactor. South Korea may also have a current nuclear submarine programme, prompted by North Korean work on submarine-launched ballistic missiles. In the late 1950s several NATO countries nearly bought American submarine power plants, but withdrew before technology was transferred. For a detailed article about the Italian programme, with excellent plans, see Michele Cosentino, 'Project 1030: A Nuclear Attack Submarine for the Italian Navy' in John Jordan (ed.) *Warship 2019* (Oxford: Osprey Publishing, 2019), pp.98–109.

4.3 TECHNOLOGICAL REVIEW

PROSUB

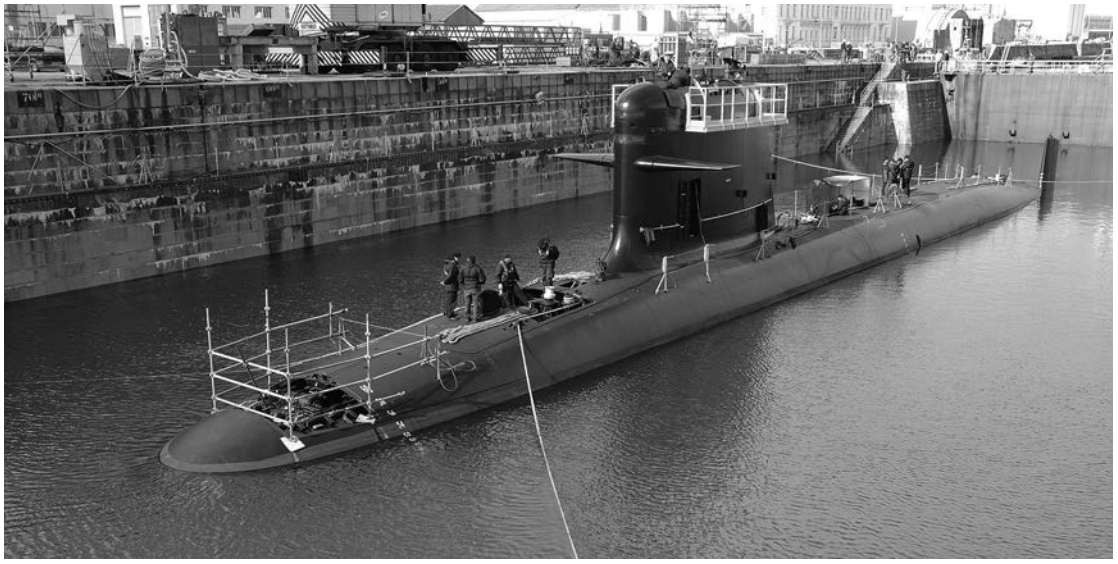
Building Brazil's Future Submarine Capability

Author:
Richard Scott

Brazil has, since the 1970s, harboured ambitions to join the select club of nations able to build and operate nuclear-powered submarines. The *Programa de Desenvolvimento de Submarinos* (PROSUB) – beginning with the construction of four new diesel-electric submarines (S-BR) and planned to culminate in the design and build of a first nuclear-powered boat (SN-BR) – is the vehicle by which the *Marinha do Brasil* is seeking to realise that goal.

PROSUB encompasses a huge programme of infrastructure development and public works, including the construction of a new shipyard and base facilities, together with a large-scale transfer of technology into the navy and local industry. It is being delivered through a series of contract arrangements that collectively address all the constituent parts of the enterprise, notably infrastructure, technology transfer, equipment supply, offset and the supply chain. The single most important player in this endeavour is France's Naval Group, previously DCNS. In 2009, it signed a series of contracts for the PROSUB programme, building on a strategic defence cooperation agreement signed by France and Brazil in December 2008. The development and delivery of the PROSUB programme has seen several thousand direct and indirect jobs created in Brazil. Over 700 more personnel are contributing to the programme in France.

Brazil's economic situation means that the PROSUB project has not been without challenges. The collapse in commodity and oil prices in 2014–15 saw the economy plunged into recession, forcing significant cuts in public spending. While PROSUB survived, the funding blight saw the programme stretched out, resulting in a schedule slippage of approximately two years against the original programme schedule.



The Chilean Navy's lead 'Scorpène' type submarine *O'Higgins*, the first of the design to be completed. Brazil's S-BRs are an enlarged variant of the 'Scorpène' type, providing additional range and endurance. *(Naval Group)*

Now, however, a decade after contracts were signed, the PROSUB programme is beginning to bear tangible results. Many major facilities are complete, and the first of the four new S-BR submarines – based on Naval Group's 'Scorpène' design – is expected to begin sea trials before the end of 2019. In parallel, the SN-BR project has now entered its detailed engineering phase ahead of starting manufacture early in the next decade.

SUBMARINE REQUIREMENT

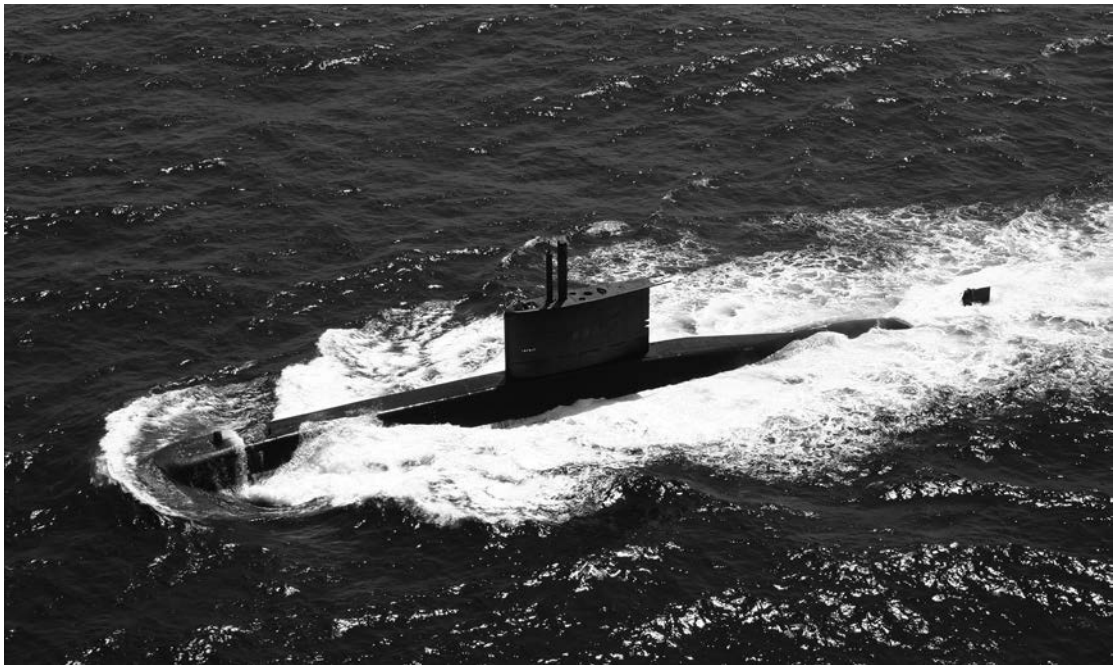
The first edition of the National Defence Strategy, published in December 2008, forms the current basis of the requirement for Brazil to build up a naval force including nuclear-powered submarines.[1] This same document emphasised four critical missions for the *Marinha do Brasil*: (i) the proactive defence of offshore oil platforms; (ii) the protection of naval and port facilities, archipelagos and oceanic islands located within Brazilian territorial waters; (iii) the ability to rapidly respond to threats against sea lanes of trade by nation states, non-state actors or criminal elements; and (iv) the capacity to join international peacekeeping operations 'out of area' under the aegis of the United Nations or other multilateral organisations. The strategy document further identified two strategic maritime access areas critical to Brazil: the littoral strip running from Santos to Vitória; and the area around the mouth of the Amazon River.

Submarines have long figured in Brazil's defence planning. The navy currently operates five conven-

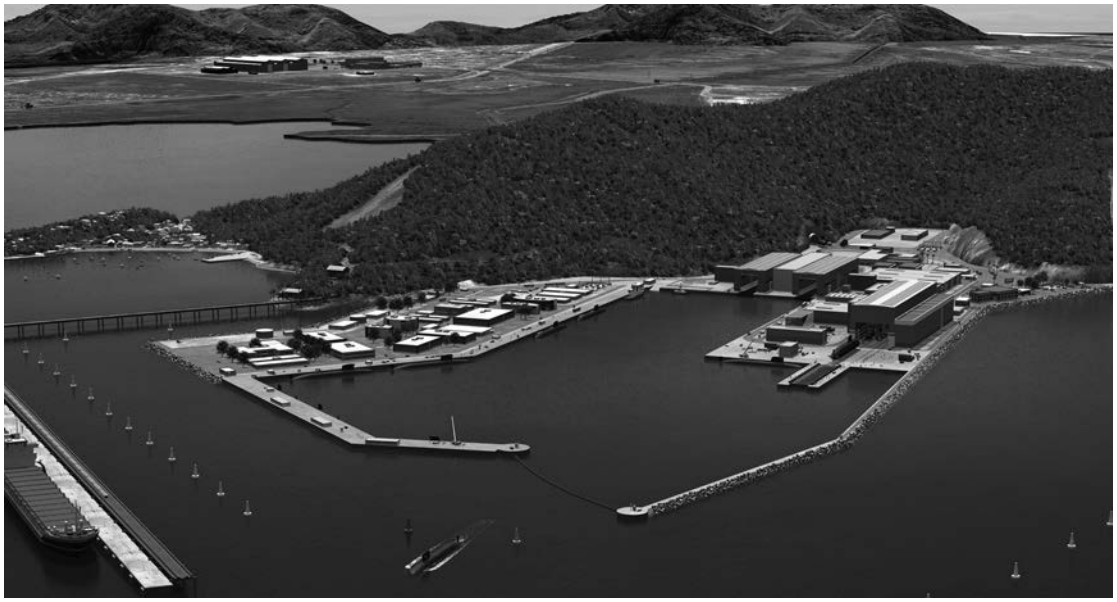
tionally-powered boats based on the German Type 209 design, all but one of which were assembled in the *Arsenal de Marinha* in Rio de Janeiro. These submarines have received a major combat system upgrade managed by Lockheed Martin. By virtue of its inherent stealth, the submarine is seen to offer a uniquely cost-effective means of sea denial. Indeed, the mere fact that a nation is able to maintain a fleet of submarines may function as a powerful deterrent.

Against this backdrop, the National Strategy of Defence stated that Brazil '… will count on a powerful underwater naval force consisting of conventional and nuclear-propelled submarines …' to ensure its sea denial objectives, continuing: 'Brazil will maintain and develop its ability to design and manufacture both conventional and nuclear-propelled submarines. It will speed up investments and the necessary partnerships to run the nuclear-propelled submarine project. [And it] will arm conventional and nuclear-propelled submarines with missiles and will develop the capacity to design and manufacture them.' With specific regard to the nascent nuclear-powered submarine programme, the National Strategy of Defence explicitly called for '… the full nationalisation and the development – at industrial scale – of the[nuclear] fuel cycle and of the reactor construction technology for exclusive use of the country'.

While Brazil has barred itself from possessing nuclear weapons, it has long advocated the development and use of nuclear technology for both defence and civilian purposes. Indeed, the navy has been at the forefront of research and development in Brazil with regard to both uranium enrichment and the design of a pressurised-water reactor. The justification for nuclear-powered submarines is rooted in their ability to remain submerged – and thus covert – for extended periods, and their ability to transit underwater at relatively high speed without the need to come to periscope depth at regular intervals to recharge batteries. What is noteworthy is that the requirement for such a capability – which brings with it significant overheads in terms of infrastructure, support and safety – is not driven by any specific external threat or risk, nor a desire to project power at extended reach. Rather, successive governments have justified the programme on the basis of the need to protect the territory, sea lanes and resources within Brazil's 3.5 million km^2 offshore zone, also known as the 'Blue Amazon'.



The Brazilian Navy currently operates five Type 209/1400 diesel-electric submarines, all but one of which were assembled in the *Arsenal de Marinha* in Rio de Janeiro. They were delivered between 1989 and 2005 and the older boats will be retired as the new S-BRs enter service, with sale to Argentina reported. These photographs show *Tapajó*, dating from 1999, and the more recent *Tikuna*, which was commissioned in 2005. *(Brazilian Navy)*



PROSUB is being developed in conjunction with France's Naval Group, one of whose responsibilities is overseeing the construction of a shipyard and naval base (EBN) to create a new submarine complex in the municipality of Itaguaí, some 70km west of Rio de Janeiro. In the foreground of this graphic of the site is the 487,000m2 *Área Sul* of the EBN, which will eventually comprise an assembly hall, a maintenance facility, an operating base and a nuclear complex. *Área Sul* is linked by tunnel to the 103,000m2 *Área Norte,* which is hidden by the hill in this picture. Further inland in the distance are the NUCLEP and UFEM engineering and manufacturing facilities. *(Naval Group)*

A photograph of the EBN's *Área Norte* taken during the course of construction in March 2015. Initially established as an industrial site for the shipyard works, it will become an administrative and security complex on completion. Note the entrance to the tunnel providing a connection to the base's *Área Sul* in the side of the hill. *(Naval Group)*

ORGANISATION AND PARTNERS

The delivery of the PROSUB programme, which is managed by the General Coordination of the Nuclear Propulsion Submarine Development Program (COGESN), is a significant and complex enterprise. It brings together both state-owned and private sector stakeholders, and major industry entities from Brazil and overseas. A navy office subordinate to the General Board of the Navy Nuclear Technological Development (DGDNTM), COGESN is responsible for managing all design, development, construction activities. In doing so, it oversees contractual arrangements and the development of indigenous technical and industrial capabilities.

Having begun negotiations in mid-2008, what was DCNS – now Naval Group – signed detailed contracts for the PROSUB programme in September 2009. The contract agreement came into force the following month, with work proper commencing in the first quarter of 2010. The French company's principal responsibilities are three-fold: first, the construction of the shipyard and base facilities to create a new naval complex in the municipality of Itaguaí, some 70km west of Rio de Janeiro; second, the transfer of technology to enable the design, manufacture and integration of the four S-BR boats; and third, technical and design assistance for the non-nuclear aspects of the SN-BR programme.

In total, Naval Group has five separate contract lines, aggregating to a total value of approximately €7bn (c. US$7.9bn), relating to PROSUB. The single biggest contract is for transfer of technology, which is split into three main parts:

- The naval shipyard/base complex, for which Naval Group has undertaken the basic design, validated the details, supported the construction process, and performed commissioning activities for all installations.
- The S-BR submarine, comprising the delivery of a technical data package and the provision of a resident team in Itaguaí to tutor shipyard

personnel on the build process.
- Transfer of technology and design support for the SN-BR submarine.

A second contract covers 'offset and nationalisation' to address Brazil's requirements for local content, while a third contract covers the material packages for the S-BR build programme (a future, fourth, contract will cover a material package for the SN-BR submarine). The fifth and final contract covers the supply of weapons and effectors for the PROSUB programme, notably F21 heavy torpedoes and CANTO acoustic countermeasures.

Itaguaí Construções Navais SA (ICN) – a special purpose entity established by Odebrecht and Naval Group – is contracted separately for submarine construction activities.[2] Although ICN is owned 59 percent by Odebrecht, Naval Group is responsible for operational control of the joint venture. EMGEPRON, as the navy's own management agent, also retains a 'golden share' to ensure that the navy's interests are safeguarded.

Civil engineering group Construtora Norberto Odebrecht has been contracted for infrastructure works in Itaguaí; the completed facilities are then made available to ICN by the Brazilian Navy. Finally, a small consortium known as Consórcio da Baía de Sepetiba (formed by Naval Group, Construtora Norberto Odebrecht and ICN) has been established to provide management support services to the COGESN project team.

Aerial view of the *Área Sul* portion of the new naval complex in Itaguaí. The capacious *Estaleiro de Construcao* assembly hall is immediately identifiable. *(Naval Group)*

INFRASTRUCTURE DEVELOPMENT

The development of the industrial infrastructure supporting PROSUB began in 2010, and is due to complete by the end of 2021. The work is focused on the creation of the new shipyard and submarine base on Sepetiba Bay, Itaguaí. The civil works have included major excavations, dredging and land reclamation, including the movement of 300,000m^3 of earth and rock. Much of this has been used to extend the *Estaleiro e Base Naval* (EBN) – shipyard and naval base – estate into Sepetiba Bay. All infrastructure at the complex is being built to strict seismic standards. Given the presence of a large nature reserve close to the EBN site, an environmental impact study was undertaken. Its detailed conclusions were accepted by the Brazilian authorities, leading to the issue of the appropriate environmental and operating licenses.

The EBN is, in fact, split into two separate sites. *Área Norte*, covering an estate of 103,000m^2, has initially been established as an industrial site for the shipyard works. On completion, it will be used as an access and monitoring zone housing administrative buildings, a bus terminal, an environmental monitoring laboratory, a nuclear decontamination centre and a nuclear, biological and chemical defence battalion. *Área Sul* comprises an area of 487,000m^2 that has been developed for submarine assembly, launch, basing and maintenance. This site is split into four main areas: an assembly hall; a maintenance facility; the naval base; and the nuclear complex. *Área Norte* and *Área Sul* are interconnected by means of a 703m tunnel. Some 14m in diameter, the tunnel is large enough to allow submarine pressure sections to pass through.

Submarine construction facilities are split across two principal sites. The *Estaleiro de Construcao* (ESC) construction hall is located within the *Área Sul* site looking out onto Sepetiba Bay. The *Unidade de Fabricação de Estruturas Metálicas* (UFEM) manufacturing, structures and outfitting facility is sited inland some 5km to the north-west adjacent to the existing *Nuclebrás Equipamentos Pesados* (NUCLEP) facility. Operating as a subcontractor to ICN for the PROSUB programme, NUCLEP is a state-owned heavy engineering plant originally built to fabricate the pressure hulls for the navy's Type 209 *Tupi* class submarines. The facility has latterly been employed to build the pressure hulls for the PROSUB programme. Once complete, pressure hull sections are moved into the UFEM facility. Commissioned in 2013, the UFEM complex is responsible for pre-outfit and equipment installation into the four pressure hull modules (each S-BR boat comprises four hull sections), and for the manufacture of light structures.

Having completed outfitting, each of the sections

is transferred by road via *Área Norte* and the interconnecting tunnel to the ESC assembly hall in *Área Sul,* the biggest building in the EBN complex. The hall – 160m in length, 33m wide and with a ceiling height of 52m – is sized to be able to accommodate two submarines at the same time.

Submarines are launched and recovered using a 110m x 20m Syncrolift ship lift rated for loads of up to 8,000 tonnes (suitably sized for the SN-BR). A partially covered apron is to be built alongside the ESC hall for dry maintenance work on the S-BR boats after they have been taken out of the water. Submarine berths will be provided on a 280m quay protected by a sea wall. As well as providing a base for the new boats, the naval base will also provide a homeport for a rescue vessel, tugs, a diving support tender and a torpedo recovery vessel.

Two 140m covered dry docks will be completed in due course as part of the SN-BR programme. A traversing reactor access house will be used to lift nuclear fuel elements in and out of submarines.[3]

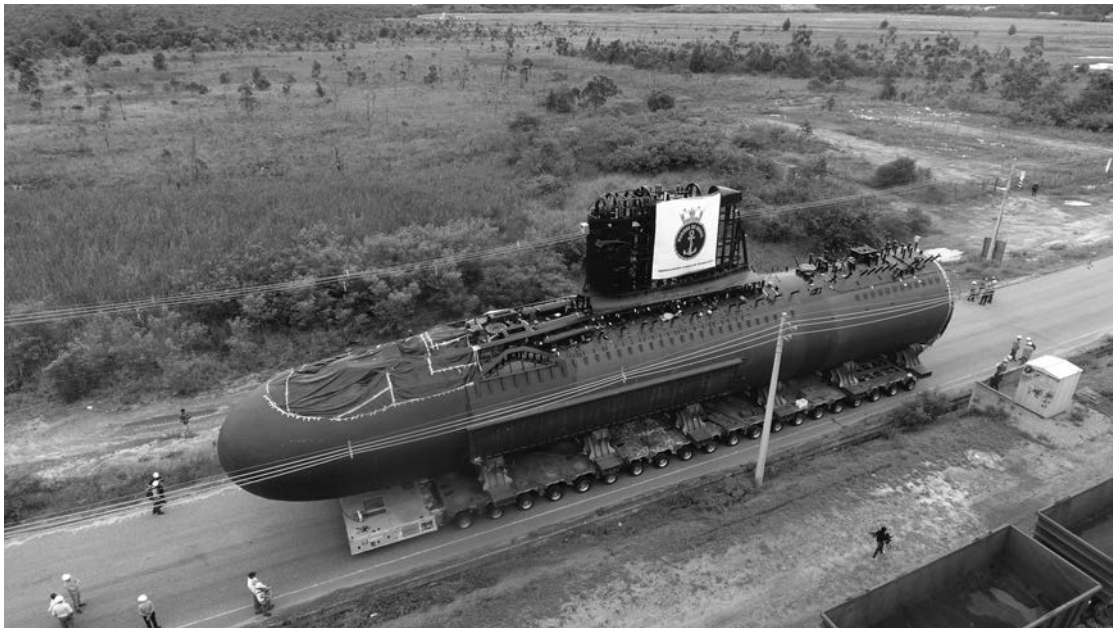
S-BR DESIGN AND BUILD

The S-BR design is a derivative of the 'Scorpène' conventionally-powered submarine, previously sold by DCNS/Naval Group to Chile, Malaysia and India. However, it has been adapted to suit the Brazilian Navy's specific requirements. At 71.6m in length, the Brazilian submarines are approximately 5m longer than their forebears: this additional volume allows for increased fuel and additional crew accommodation to meet the *Marinha do Brasil*'s requirements for extended range and endurance, the latter reportedly in excess of 45 days. Each S-BR submarine is fitted with six 533mm torpedo tubes. There is space for up to eighteen weapons on board, comprising a mix of Naval Group F21 heavyweight torpedoes and MBDA SM39 anti-ship missiles.

Production of the forward sections of the first of class, named *Riachuelo*, began in May 2010 at Naval Group's shipyard in Cherbourg. Construction activities began in France because the facilities in Brazil were not ready at that early stage of the programme. It also provided an opportunity for the first Brazilian production teams to receive hands-on training in France. About 150 personnel from the Brazilian Navy, ICN and NUCLEP were sent to Cherbourg to receive instruction. In addition, a number of Naval Group personnel have been posted to Brazil to oversee training activities in-country.

Under the transfer of technology agreement, Naval Group has provided training to Brazilian personnel drawn from the navy, government, and industry. In 2011 a team of approximately twenty officers and engineers received training in Cherbourg on submarine outfitting studies, while a separate twenty-strong team was brought to Lorient for training on submarine logistic support. Naval personnel have also been deputed to other industrial sites in France for specialised instruction in submarine combat systems (Toulon), sonars (Sophia-

Initial fabrication facilities for PROSUB are conducted at *the Unidade de Fabricação de Estruturas Metálicas* (UFEM) manufacturing and outfitting facility and the adjacent, existing *Nuclebrás Equipamentos Pesados* (NUCLEP) factory. These are about 5km inland of the EBN. *(Naval Group)*



Opposite and this page: A series of images of the largest hull section of *Riachuelo* being transferred by road from the UFEM manufacturing plant via the tunnel linking the EBN's *Área Norte* and *Área Sul* to the *Estaleiro de Construcao* assembly hall on 14 January 2018. *(Brazilian Navy)*

Antipolis), major platform equipment (Ruelle) and heavyweight torpedoes (Saint-Tropez).

SUPPLY CHAIN

A major part of Naval Group's responsibility under the PROSUB project has been to identify and qualify Brazilian companies as part of the submarine

In one of the many ceremonies held to mark PROSUB's progress, *Riachuelo*'s sections are joined in the ESC assembly hall in February 2018. *(Brazilian Navy)*

supply chain. The company has an offset obligation valued at approximately €400m. The intention is to grow industrial competency in-country and to allow the Brazilian Navy to rely increasingly on a sovereign national industrial base. To date, approximately fifty suppliers from across Brazil have been qualified. Of these, some are indigenous businesses, while others are local subsidiaries of international companies.

Approximately 100 Brazilian companies have participated in the production of systems and subsystems for the S-BR submarines. This includes the manufacture of some combat system equipment, including the torpedo tubes, weapon-handling equipment, the combat management system and sonar systems. Local suppliers for PROSUB include Micromazza (valves and foundry), Bardella (metal-work and weapon handling), Adelco (switchboards, transformers and battery charging), and Atech (combat system multifunction consoles). Thales subsidiary Omnisys has been qualified to produce and support sonar systems for PROSUB, and to build control stations.

The S-BR submarines are equipped with Naval Group's own SUBTICS combat system. The combat system shore integration facility is located at Saint-Mandrier, near Toulon in southern France. This

Riachuelo pictured just prior to and after launch via the ship lift at EBN Itaguaí on 14 December 2018. The ceremony was attended by then president Michel Temer and president-elect Jair Bolsonaro in a sign of PROSUB's national significance. *(Naval Group/Richard Scott NAVYPIX)*

activity began in January 2014, building up to the completion of the full combat system at the end of 2015. The need to tailor SUBTICS to meet the specific national requirements of the PROSUB programme has seen Naval Group establish a transfer of technology agreement with Fundação Ezute. A team from Ezute was sent to France, as was a team from the Brazilian Navy, to gain insight into the embedded software architecture: these personnel now serve as the core of a multidisciplinary team given responsibility to develop and sustain the combat system in-country.

Naval Group has also taken responsibility for the build and delivery of four simulators to support crew training. All were built by the company's Angouleme factory.

PROJECT PROGRESS

The first S-BR boat, *Riachuelo*, was lowered into the water on the ship lift at Itaguaí on 14 December 2018 during an official launch ceremony attended by then president Michel Temer and president-elect Jair Bolsonaro. Following the completion of setting-to-work, test and commissioning activities alongside, *Riachuelo* is planned to commence sea trials in the last quarter of 2019. Handover to the *Marinha do Brasil* is planned to follow in the second quarter of 2020.

Work continues on the three follow-on S-BR submarines. Following outfitting at the UFEM facility, the main hull sections of the second boat, *Humaitá*, have been transported to the ESC construction hall facility during 2019 for consolidation and integration. Work on the remaining boats, *Tonelero* and *Angostura*, is continuing inside UFEM. Delivery of all four of the conventional S-BR boats is due to complete by the end of 2023.[4]

NUCLEAR AMBITION

The ultimate objective of the PROSUB programme is to enable Brazil to commission the first SN-BR submarine, to be named *Álvaro Alberto* in honour of the man regarded as the father of the navy's nuclear programme. The navy's long-term plan envisages a class of up to six SN-BR boats.

The Brazilian Navy has been developing a submarine reactor plant for more than three decades (in November 2018 the service celebrated 30 years of operation of the MB-01 reactor developed in conjunction with the Institute for Energy and Nuclear Research). Development of the multipurpose pressurised water reactor is centred on the Nuclear Power Generation Laboratory (LABGENE) at the Aramar Nuclear Industry Centre in Iperó.

SN-BR design activity is continuing to mature the detail design and data package of Brazil's proposed nuclear-powered submarine ahead of the start of production, currently planned for 2022. *(Brazilian Navy)*

Between 2010 and 2012, a team of thirty-one engineers (comprising twenty-five naval officers and six civil servants) received theoretical training in France to provide the core of the SN-BR Project Technical Body. The SN-BR project was formally established in July 2012 at the COGESN Technical Project Office, located at the *Centro Tecnológico da Marinha em São Paulo* (CTMSP).

Subsequently, Amazul (Amazônia Azul Tecnologias de Defesa) was established in 2013 with the objective of nurturing and sustaining key sovereign technologies in support of the navy's nuclear programme, PROSUB, and the national nuclear enterprise. The company's primary mission is to support the development of SN-BR through the provision of suitably qualified and experienced personnel: the SN-BR project estimates a total requirement for 600 qualified personnel at the programme's peak.

Phase A of the SN-BR design activity – concept and feasibility studies – concluded in July 2013. This was followed by a Phase B preliminary design task running from August 2013 to January 2017. Naval Group has delivered technology and design models to support the Project Technical Body.

The SN-BR design activity undertaken to date has produced in a nuclear-powered submarine design somewhat larger than the S-BR (the increase reflecting the need to incorporate the reactor plant and associated secondary machinery). Particulars released by the *Marinha do Brasil* indicate a displacement of 6,000 tons, a length of 100m and a pressure hull diameter of 9.8m (compared to 6.2m in the S-BR). Beginning in early 2019, Phase C activity is continuing to mature the design and data package. This will generate a detailed construction plan, materiel package and global cost estimate to allow for the commencement of construction activities (Phase D).

The build programme long promulgated by the *Marinha do Brasil* had anticipated construction of SN-BR beginning in early 2020, with launch following in 2027, and delivery in 2029. However, latest reports suggest that Phase D activities will not now begin until 2022, with launch to take place in 2029. Given the inevitable complexities associated with first-of-class test and commissioning, the introduction to service of *Álvaro Alberto* would not likely occur until the early 2030s.

Notes

1. See *Estratégia Nacional de Defesa* (Brasília: Ministério da Defesa, 2008).

2. Odebrecht is a large Brazilian business conglomerate operating in the construction, engineering and petrochemicals sectors. It has recently been overshadowed by a corruption scandal relating to the alleged payment of bribes to Brazilian and other Latin American politicians.

3. In similar fashion to French nuclear-powered submarines, SN-BR will use low-enriched uranium that necessitates periodic refuelling of its reactor. This contrasts to the use of highly-enriched uranium by the United States and the United Kingdom, which has permitted the development of 'whole life' or 'one shot' reactor cores.

4. When PROSUB was first contracted, it was anticipated the first S-BR would be delivered in 2017, itself a delay on previous ambitions, and the remaining three at regular intervals through to 2021. This suggests a c. 24–30 month delay to this element of the programme.

5. Portuguese-speaking readers with an interest in PROSUB can follow developments on the Brazilian Navy's website for the programme at: https://www.marinha.mil.br/prosub/

Contributors

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Norman Friedman: Norman Friedman is one of the best-known naval analysts and historians in the US and the author of over forty books. He has written on broad issues of modern military interest, including an award-winning account of the Cold War, whilst in the field of warship development his greatest sustained achievement is probably an eight-volume series on the design of different US warship types. Amongst recent works, *Winning a Future War: War Gaming and Victory in the Pacific War* – a description of the way that war gaming at the US Naval War College helped the US Navy prepare for the Pacific War – produced for the Naval History & Heritage Command stands out as a notable contribution to naval history. His latest book is *British Submarines in Two World Wars*, the first part of a two-volume assessment of Royal Navy submarines to be published by Seaforth. The holder of a PhD in theoretical physics from Columbia, Dr Friedman is a regular guest commentator on television and lectures widely on professional defence issues. He is a resident of New York.

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Richard Scott: Richard Scott is a UK-based analyst and commentator who has specialised in coverage of naval operations and technology for over 25 years, with particular interests in the fields of naval aviation, guided weapons and electronic warfare. He has held a number of editorial position with Jane's, including the editorship of *Jane's Navy International* magazine, and is currently group Consultant Editor – Naval. Mr Scott is also a regular contributor to several other periodicals including the *Journal of Electronic Defense*, *Unmanned Vehicles*, *Defence Helicopter* and *Warship World*.

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Conrad Waters: A lawyer by training but banker by profession, Conrad Waters was educated at Liverpool University prior to being called to the bar at Gray's Inn in 1989. His interest in maritime affairs was stimulated by a family history of officers in merchant navy service and he has written on naval matters for over 35 years. This included six years producing the 'World Navies in Review' chapter of the annual *Warship* before assuming responsibility for *Seaforth World Naval Review* in 2009. He also edited *Navies in the 21st Century* – shortlisted for the 2017 Mountbatten Maritime Award – whilst his latest book – *British Town Class Cruisers* – will be published at the end of 2019. Conrad is married to Susan and has three children: Emma, Alexander and Imogen. He lives in Haslemere, Surrey.

Front cover: main *Indiana (US Navy)*; top left to right: *Aslat (Conrad Waters)*; F-35B *(Crown Copyright 2018)*; *Admiral Makarov (Crown Copyright 2018)*; *Helge Ingstad (Norwegian Armed Forces/Jakob Ostheim)*; **Back cover:** main: Littoral Combat Ships at Marinette Marine *(US Navy)*; inset: *Tidespring (Crown Copyright 2018)*

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